BEHAVIOR OF SHIELD SUPPORT IN LONGWALL MINING

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
BACHELOR OF TECHNOLOGY
IN

MINING ENGINEERING
BY

CHANDAN KUMAR

110MN0392

Department of Mining Engineering
National Institute of Technology
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Under the Guidance of

Prof. S. Jayanthu

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CERTIFICATE

This is to certify that the thesis entitled, - "***BEHAVIOR OF SHIELD SUPPORT IN LONGWALL MINING***" submitted by **Mr. Chandan Kumar**, **109MN0392**, in partial fulfillment of the requirement for the award of Bachelor of Technology Degree in Mining Engineering at the National Institute of Technology, Rourkela (Deemed University) is a record of original research work carried out under my supervision.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any University/Institute for the award of any Degree or Diploma.

Prof. S. Jayanthu

Department Of Mining Engineering

National Institute of Technology

Rourkela – 769008

Date:

ACKNOWLEDGEMENT

First and foremost, I express my sincere appreciation and gratitude to Prof. S. Jayanthu for allowing me to carry on the present topic "**Behavior of Shield Support in Longwall Mining**" and later on for their inspiring guidance, constructive criticism and valuable suggestions throughout this project work. I am very much thankful to them for their able guidance and pain taking effort in improving my understanding of this project.

I would also like to extend our sincere thanks to the Mr. D.Lalit Kumar, Mines Manager of GDK 10 Inc, SCCL and other officials, who helped me during my sample and data collection in their respective regions.

Last but not the least; I would like to thank all my friends who have patiently extended all sorts of helps for accomplishing this project.

Chandan Kumar

Department of Mining Engineering

National Institute of Technology, Rourkela

Date:

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ABSTRACT

Field observation were conducted on behaviour of chock shield support of capacity 800T during extraction of longwall panel no. 3D2 at 250 m depth and 150 m face length of GDK 10A Incline, Singareni Collieries Company Limited. Chock leg pressures and leg closures were regularly monitored at different stages of extraction of longwall panel.

During extraction of the panel, maximum leg closure and pressure on the chock shield were 600 mm and 490 bar, respectively (not on all chocks). Setting and yielding pressures were 300 bar and 400 bar corresponding to setting load and yielding load 600 T and 800 T, respectively. During major fall condition, 27% of chock shields were loaded upto 800T. During normal periods, maximum load was about 640T.

Parametric studies for depth covers of 150 m to 1200 m for the face advance of 6 m to 150 m was simulated in 2D numerical model. At each depth, a fall in vertical stress was found between 80 m to 100 m face advance indicating major roof fall and for 250 m depth cover, it was varying from 6 MPa to 4.5 MPa. Vertical stress and roof sag above the support was increasing as the depth was varying from 150 m to 1200 m and maximum found was 50 MPa and 1500 mm respectively at 1200 m depth and 150m face advance.

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CHAPTER 1

INTRODUCTION

1. INTRODUCTION

The success of longwall mining depends to a large extent on the capacity and design of shield support. Throughout the history of longwall mining, shield support design has been a critical issue to the success of mining operation. To make mining operations safe and sound the study of behavior of shield support and its design is very essential for complete success of the mine. Support design and prediction of its behavior are very essential in determining the type of mechanism to be practiced for better production and benefit. A lot of studies and researches has been carried out in the field of behavior of shield support.

India stands in third position among largest coal producers in the world having a reserves of around 240 billion tones. The shallow coal seams which are extracted through opencast mines, are gradually being exhausted. So, taking this consideration, researchers are focusing to develop a highly productive underground methods that can be used to extract coal at a faster rate and can fulfill all the demand of power. So bulk production and safer modes of extraction has become important for future needs. The most proven and efficient method till now is longwall technology which is highly productive as well as safer.

The first mechanized longwall mining in India was practiced in Moonidih colliery in August 1978. After that popularity of longwall began to increase due to its high production rate. SCCL has been a pioneer in the field of longwall technology. Even SCCL was not the first company to implement the longwall technology in India but its high success rate in longwall technology has set a milestone for other mining companies. Its production is 3000-4000t/day they which can be compared to opencast mining methods.

Longwall technology was first implemented in SCCL in 1983 in GDK7/ VK7 mines where two faces was successfully extracted. After that equipments were shifted to GDK 11 A, where it was proved unsuccessful because of the poor strata and underrating of supports. After that improved power supports were brought and implemented in GDK 10A Incline which was proved very successful and production rate was increased and a yearly production of about 3.5MT.

1.1 Objectives of the Project

This study is focused on behavior of shield support in longwall mining and shall concentrate to evaluate on the following areas:

- To study the shield behavior in a underground longwall coal mine
- Simulation of the field conditions in FLAC 5.0 software.
- Interpretation of the results generated from simulating the models in FLAC 5.0 to determine the shield behavior.
- To validate the results generated against the data collected from the mine.

1.2 Methodology

Following steps were taken to fulfill the study:

- Longwall panel 3D2 of GDK 10A Incline was chosen for detailed study of project.
- Data related to chock shields was collected for database analysis.
- The Geotechnical conditions of a panel of that mine were simulated in models.
- Analysis of results
- Conclusion

CHAPTER 2

LITERATURE REVIEW

2. LITERATURE REVIEW

Longwall technology in mining is a relatively very new and successful methods compared to other methods and now it is getting more popularity due to its high production rates and safety parameters. It is evolving with new techniques, technology, equipment, face management practices and systems appearing as a direct means to continually improve all aspects of operational and financial performance.

Longwall mining is very successfully practiced in USA, Australia and also in China which are the major coal producers in the world. Developed countries mainly use this technology for the coal production and it can be said that major development in this technology has been done by these nations. Though this technology is not very successful in India due to varied reasons, but SCCL has brought a revolution in the Indian scenario by successfully using longwall mining at a large scale for extraction of coal.

2.1 Longwall Mining Method

A longwall panel is about 1000 to 2000 meters long with a typical width of around 150-200 meters and for a seam of thickness near about 3-4 meters. This can be assumed as a very long and wide pillar with modes of access on either sides. These mode of access are termed as “gate roads” and “tail roads”. For extracting the coal from the panel, double drum shearer is used and the roof at the face is supported by shield supports. The coal is extracted by the repeated back and forth movement of the shearer along the coal face. The cutted coal is transported to a conveyor chain called armoured conveyor chain to the bridge stage loader where they are crushed to smaller pieces and from there it is transported to the surface with the help of conveyor belts.

The Longwall mining has numerous advantages over the conventional mining methods which include:

- high Recovery of coal
- lower Operating Costs
- Easier to Supervise.
- Easier to train Miners.
- Works under weak roof.

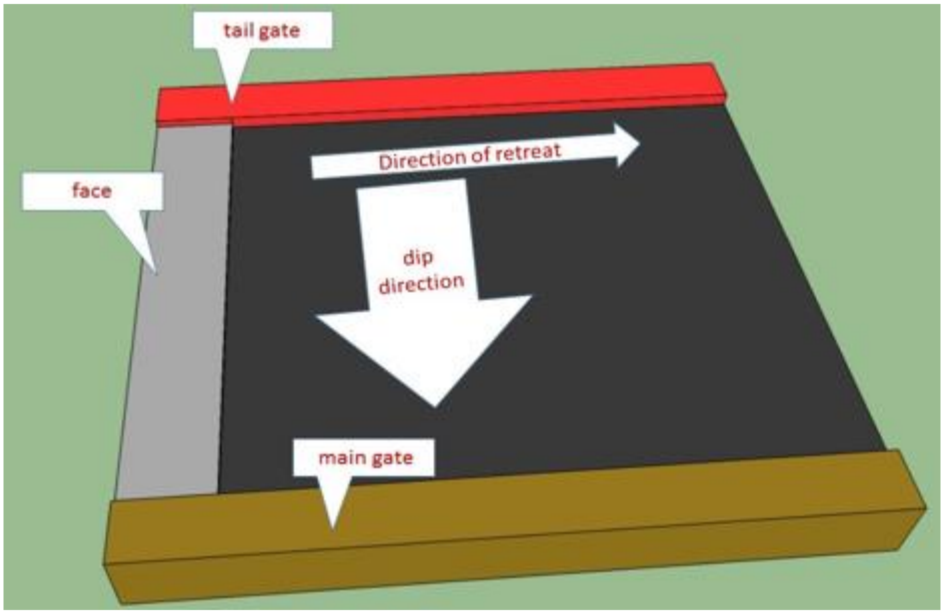

Fig. 2.1: Longwall mining method

2.2 Behavior of Shield Support

Success of longwall almost depends upon performance of shield supports. So it becomes necessary to have information about shield behavior in different geological condition. The factors influencing the load coming on supports are setting load density, height of caving block, yield characteristic of supports and fractured zone near the face.

Roof support selection should take into consideration (Source: G W Mitchell):

1. Support resistance
2. Roof and floor pressure distribution

3. Cutting height range
4. Collapsed and transport height
5. Travelling access through the support
6. The setting and yield pressure
7. Hydraulic circuit
8. Support control system and,
9. Speed of operation

Support load and resistance:

The relationship between the load generated by a shield and the stiffness of support in terms of roof sag is critical in controlling the roof above the longwall. The capability of the shield to control roof above it can be expressed in terms of ground reaction curve.

2.2.1 Mechanics of roof behavior and shield loading (Source: M. Barczak)

Most of the roof structure is capable of transferring its weight on solid coal in front of face and on goaf material as the face advances. Immediate roof are less stable and immediately separate from the roof as the face advances. So, shield support should be capable of holding this vertical load and horizontal load coming due to strata dynamics.

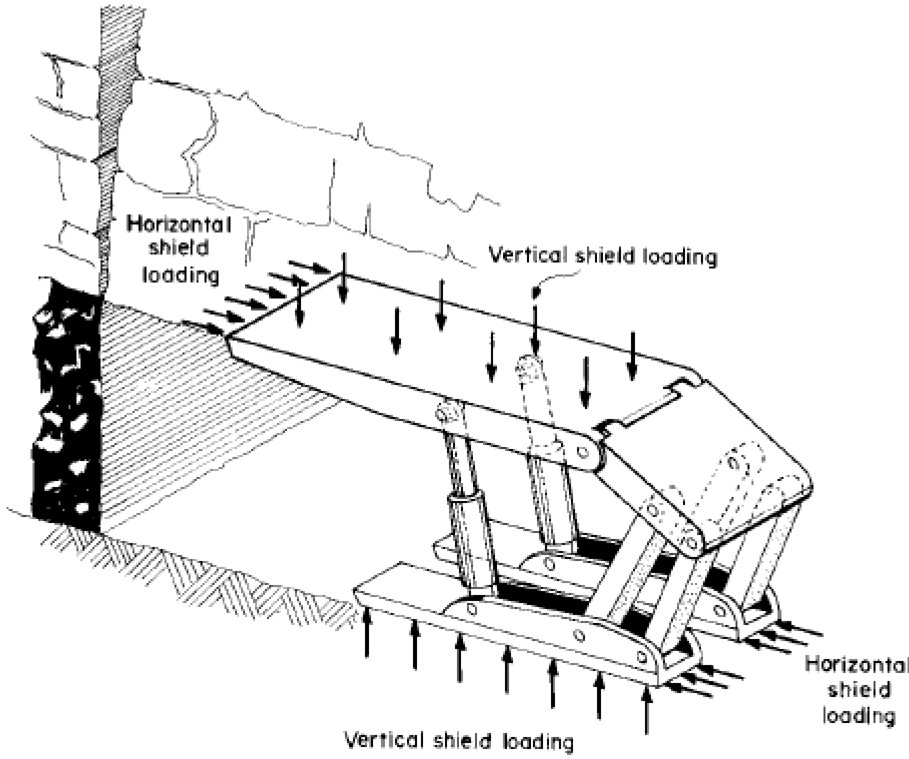

Fig.2.2: Horizontal and vertical force produced from strata dynamics (Source: M. Barczak)

Loading distribution among the supporting elements must follow the conservation of energy law, i.e. total work done by coal, shield supports and goaf material must be equal to the roof loading. The required support capacity is determined by estimating the height of caving zone.

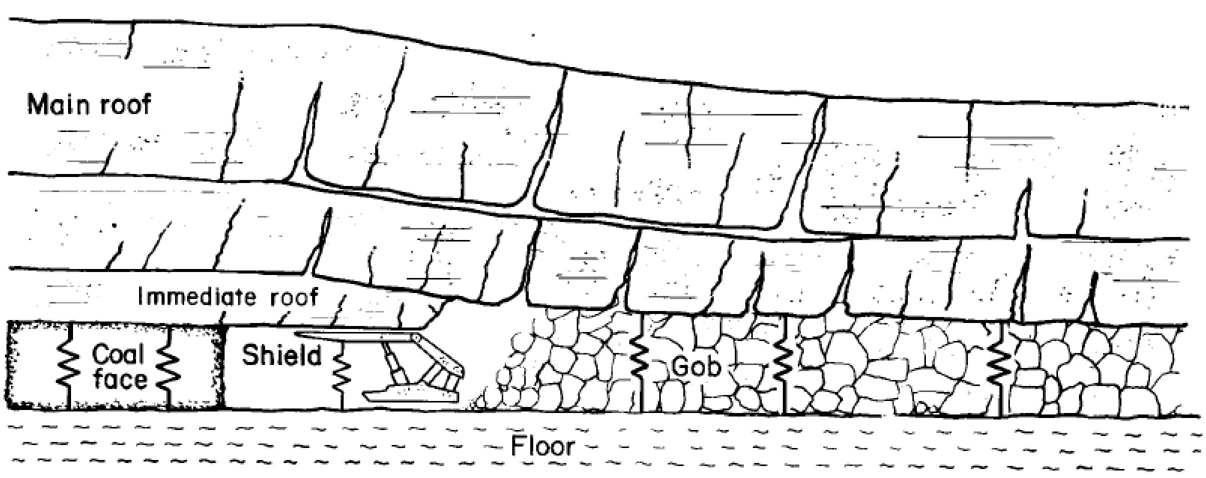

Fig.2.3: Roof behavior and shield loading (Source: M. Barczak)

2.2.2 Effects of Load Distributions in Front and Rear Legs (Source: M. Barczak)

When the load in front leg is higher, horizontal force acts towards the face and as a result, no tensile stress in immediate roof exposed between canopy tip and dace line. It implies a stable roof condition. Conversely, when the load in front leg is smaller, horizontal force acts towards the goaf resulting in an unstable roof condition.

2.2.3 Working under Weak Roofs (Source: M. Barczak)

Problem encountered working under weak roofs are generally breaking of roof over rear half of canopy. If the caving line moves forward of line of resultant thrust, then back leg will try to push upward into broken roofs. This will cause lowering of front portion resulting in essentially unsupported roofs over AFC and this may also cause the damage of shield supports.

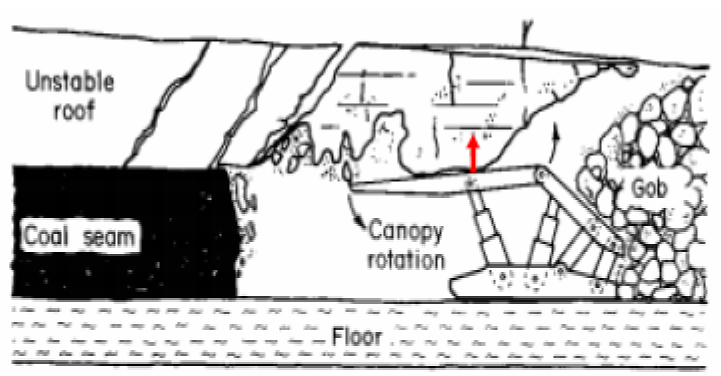

Fig.2.4: Working under weak roof (Source: M. Barczak)

2.2.4 Roof sag over Shield Support (Source: M. Barczak)

Strata behavior from the perspective of support loading can be categorized into four categories:

a. Main roof sag

b. Periodic weighting

c. Free block formation in the immediate roof, and

d. Deflection of immediate roof beam

Main Roof sag

Shield has no influence on main roof sag, so in case of main roof sag setting pressure should be reduced to provide necessary accommodation of main roof.

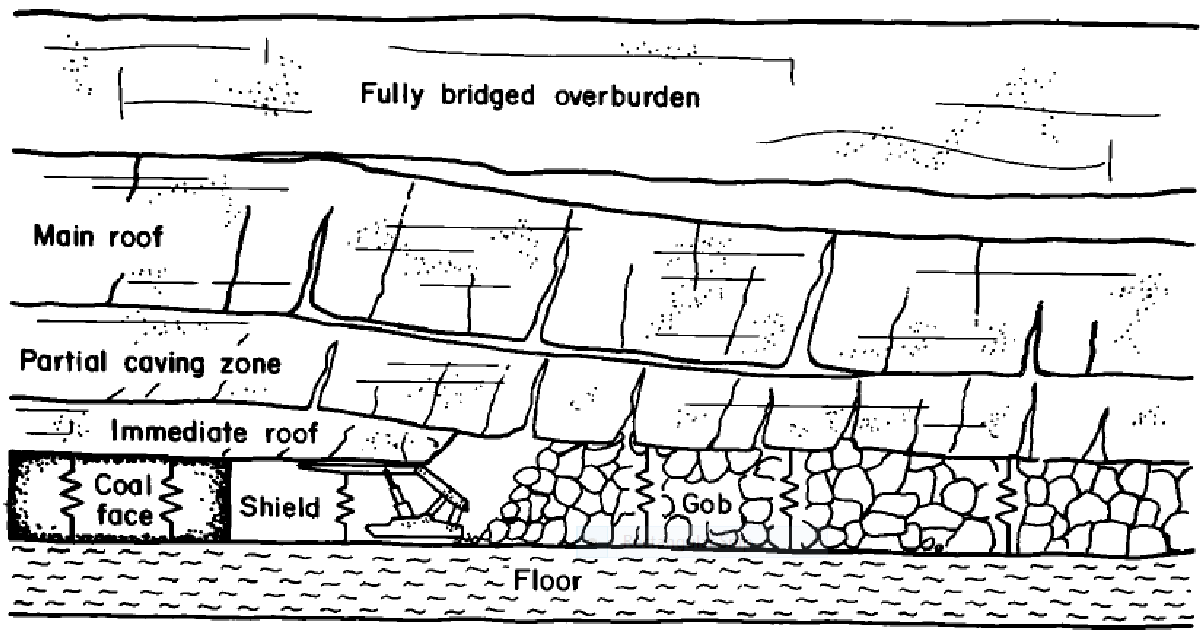

Fig.2.5: Main roof sag (Source: M. Barczak)

Periodic Weighting

Periodic weighting is generally develop in main roof or partial caving zone. Like to main roof sag, support has no influence on periodic weighting. So, for controlling the periodic weighting, setting pressure is reduced.

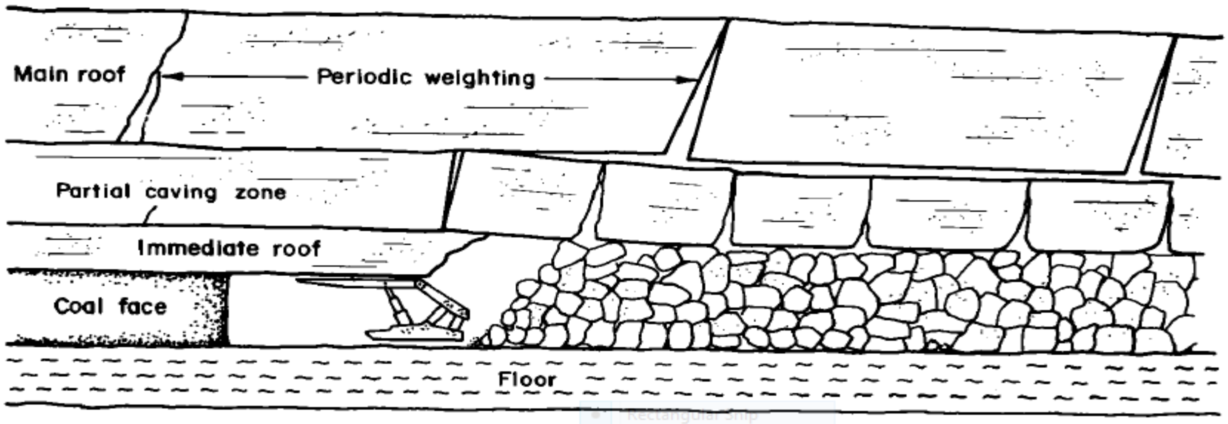

Fig.2.6: Periodic weighting (Source: M. Barczak)

Formation of a Free Block

The front abutment pressure has potential to create free block formation as the coal is removed. Shield can equilibrate this strata but has no control on its formation. For equilibrate this block, a support capacity equal to that block is required. So, to avoiding wasting available capacity, only nominal setting capacity is required.

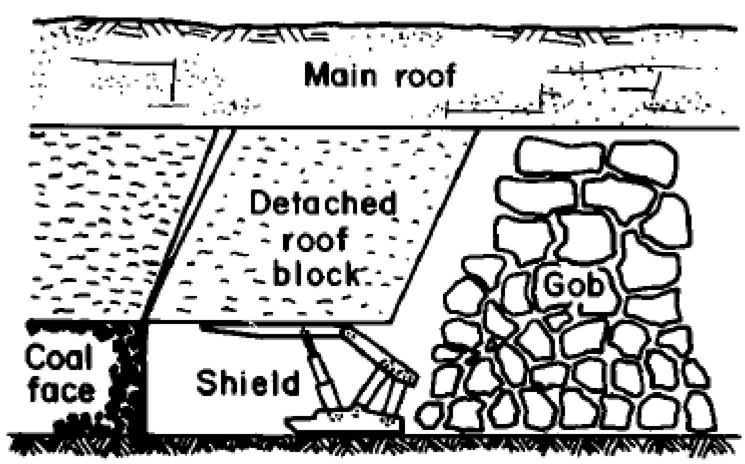

Fig.2.7: Detached immediate roof (Source: M. Barczak)

Deflection of Immediate Roof Beam

Shield resistance can more influence the deflection of immediate roof. Deflection of immediate roof decreases with increase in shield stiffness. Deflection of immediate roof also depends upon shield resistance if it is capable of preventing the bed separation or providing the sufficient friction resistance to prevent the slippage of layers from each other.

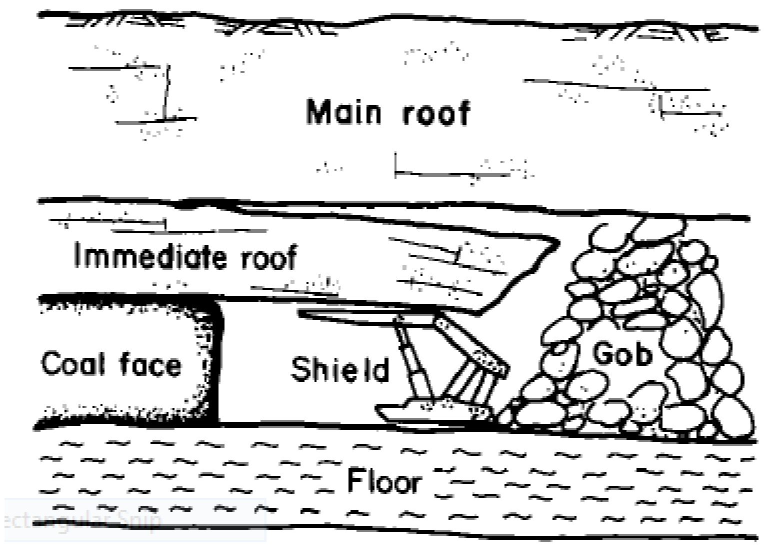

Fig.2.8: Deflection of immediate roof (Source: M. Barczak)

2.3 Numerical Modelling

Numerical modelling is a powerful tool to solve the problem related to rock mechanics in various area like civil and mining engineering. Understanding of caving behavior of rock is the primary need to control the strata and estimating the capacity of shield support in longwall. Various norms and method has been developed to predict the behavior of strata but they have very limited application due to based on some empirical equations and two dimensional beam theories. It is very difficult to predict the behavior of each section of roof with these equations. So, there is a need of something which can predict the behavior of each section of roof carefully. In these consideration, numerical modelling has a wide application. Development in area of numerical modelling, it become easy to predict the geological behavior. Now, we can simulate the field conditions in these numerical modelling softwares and can analyse it in very easy way and success fully.

2.3.1 FLAC

FLAC is an explicit two dimensional finite difference program, which can simulate the geological conditions related to civil and mining field. It provides the facility of simulating the underground extraction with support like roof bolting, hydraulic props, cable bolting, simple props, beams etc.

It creates grids with different zones and divide the problem into small parts. It analyze each small zones separately. Many parameters like vertical and horizontal stress, vertical and horizontal displacement, vectors of these parameters can be plot. It is also capable to calculate factor of safety.

Problem Solving With FLAC (Source: Itasca, 2005)

The problem is solved by using FLAC in the following sequence of steps:

- Grid generation
- Boundary and initial conditions
- Loading and sequential modeling
- Choice of constitutive model and material properties
- Ways to improve modeling efficiency
- Interpretation of results

Steps for Numerical Analysis In Geo-mechanics

Step 1: Define the Objectives for the Model Analysis

Step 2: Create a Conceptual Picture of the Physical System

Step 3: Construct and Run Simple Idealized Models

Step 4: Assemble Problem-Specific Data

Step 5: Prepare a Series of Detailed Model Runs

Step 6: Perform the Model Calculations

Step 7: Present Results for Interpretation

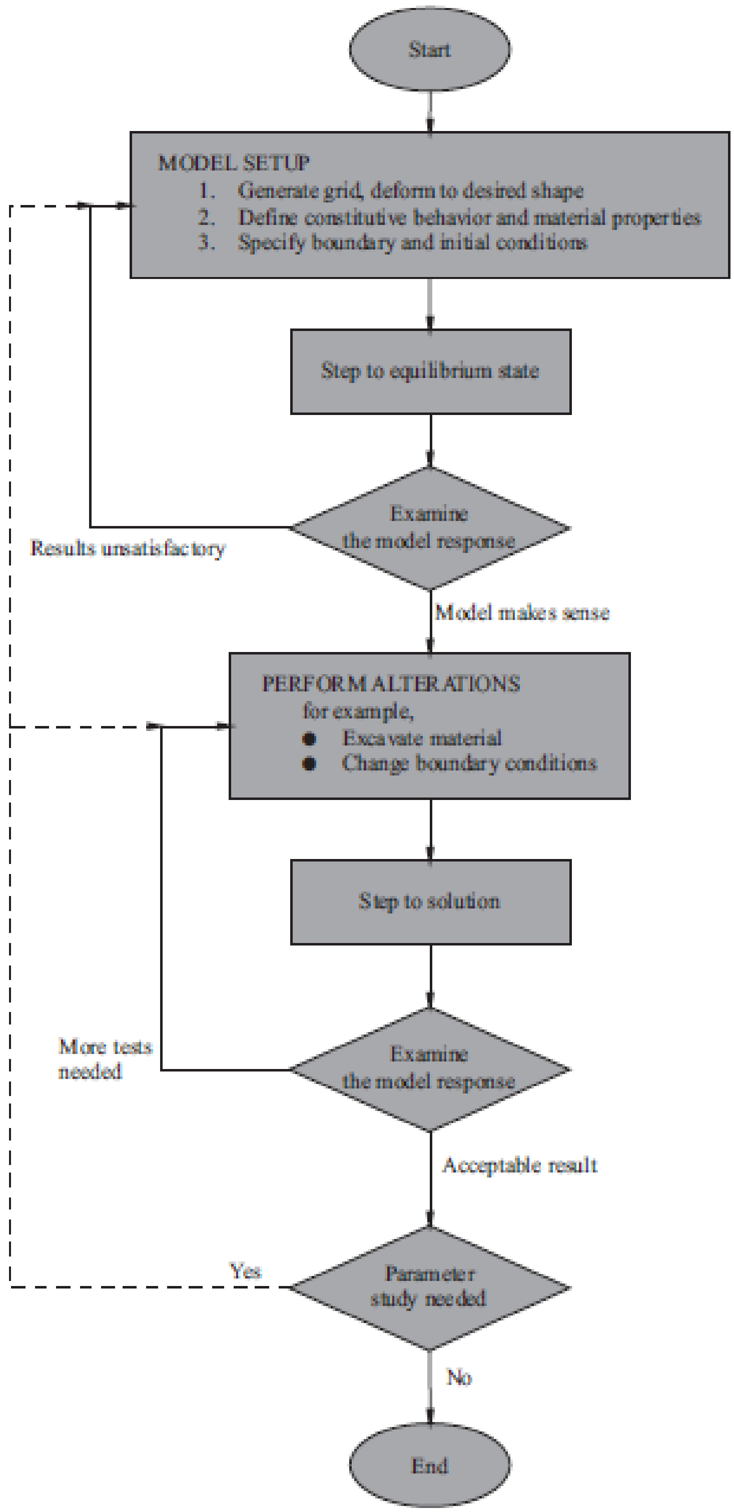

Fig.2.9: General solution procedure in FLAC (Itasca, 2005)

Table 2.1: Behavior of Shield Support Analysis by other Investigators

Year	Author	Title	Description
1987	S.S. Peng	Support capacity and roof behavior at longwall faces with shield supports	He examined the behavior of roof, floor and support on longwall faces equipped with hydraulic powered supports. He found that the most important factor in determining face stability was periodic weighting. He designed an empirical equation for support capacity.
1992	Thomas M. Barczak	Examination of design and operation practices for longwall shields	He described the details of design criteria of shield supports. He also observed that load distribution among the supporting elements must follow the law of conservation of energy in such a way that combined work of coal, powered

			supports and goaf must be equal to the load imposed by strata.
2002	Ramaiah and Lolla	Selection of Powered Roof Supports for Weak Coal Roof	They suggested that width and length of longwall pillars influence significantly the stress abutments, goaf formation, support requirements, and other factors. The face length should be sufficient wide to allow full caving, bulking and reconsolidation of the overburden strata. The goaf must be able to support the load coming on it.
2011	B Ramesh Kumar and others	Selection of powered roof supports- 2-leg shields vs 4-leg chock shields	They observed that in case of week immediate roof condition, at the time of main and periodic weightings, the front legs were more loaded than rear legs because of crumbled and

			premature caving nature of immediate roof.
2013	G. Benerjee	Application of numerical modeling for strata control in longwall mining	He presented the overview of division of caving strata in cola measure formation and details of observation of load on support at the face, movement of the strata overlying the coal seam in a typical underground coalmine along with application of three dimensional numerical model.
2013	M.S.V Ramayya and others	Design of longwall panel- A case study for no.2 seam of Ramagundam area, SCCL	They predicted the distance of local, periodic and main fall and capacity of supports at the time of these falls.

CHAPTER 3

GEOMINING CONDITION

3.1 Geological and Mining Conditions

GDK.10A Incline is situated at Ramagundam Area III of SCCL in Karimnagar District of Andhra Pradesh in the Godavari valley coal field. GDK 10A Mine covers an area of 855.7 Ha at present i.e. between Longitude 79^0 33' 45" to 79^0 35' and North latitude of 18^0 38' 15" to 18^0 41' 45".

The longwall panel 3D2 is situated in front the fault crossing at 206 m of 3D1 panel (already extracted). The present panel is in the north side. Workings were carrying out in the 6 m thick no. 1 seam. The seam is dipping at about 1 in 6; the depth of the workings is 187 m minimum and 260 m maximum. The borehole section is shown in Figure 2. The longwall face was extracted along the dip-rise and was retreated in strike direction.

The 6 m thick seam was being worked in the middle section to a height of about 3 m, leaving 2 m thick coal in the immediate roof. It was overlain by a 0.8 m thick clay band, and the thicker and stronger members of medium grained white sandstone forms the main roof.

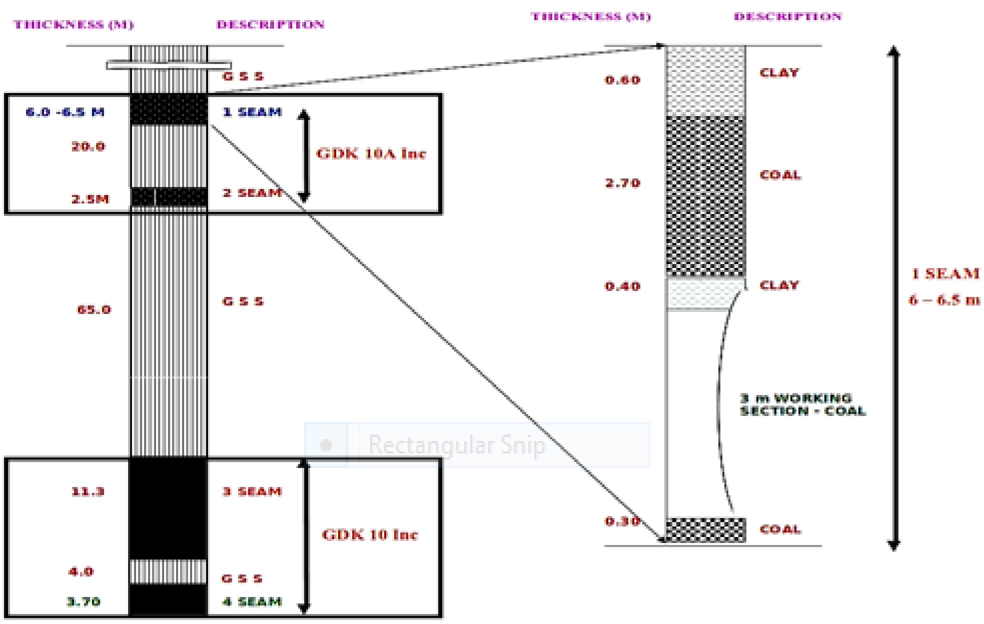

Fig.3.1: Borehole data of the GDK 10 A Incline

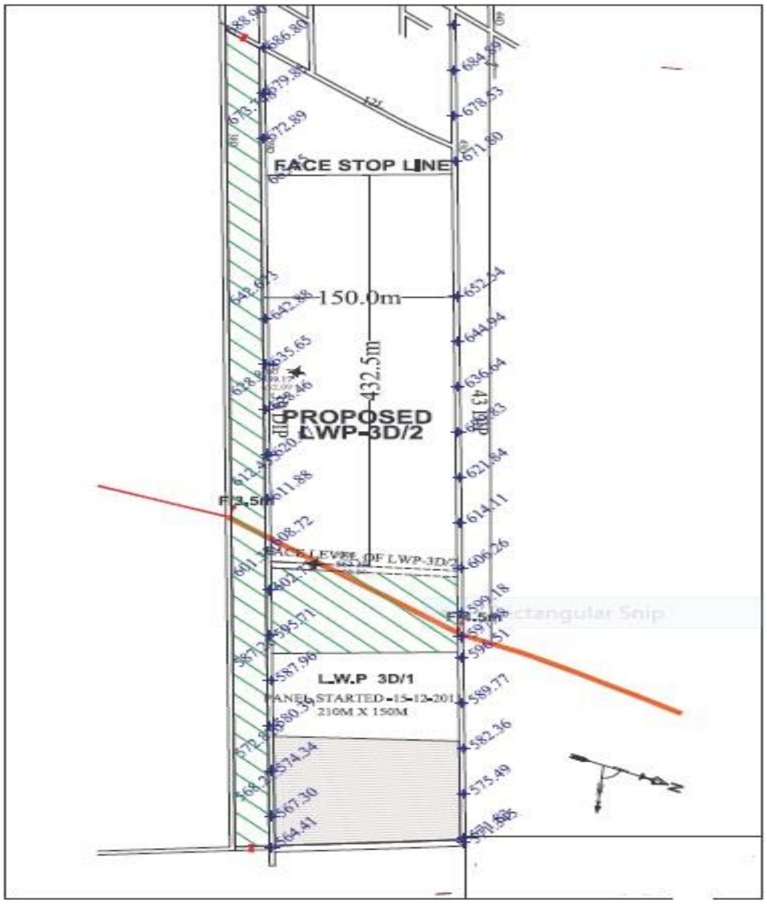

Fig.3.2: Fault crossing between 3D1 and 3D2 panel

Table 3.1: Details about the panel 3D2

Name of the seam	:	No.1seam
Depth	:	Max - 310 M, Min -175 M
North side workings	:	LW Panel 3E (Virgin)
Length of the panel	:	432.5 M
Face length	:	150 M
Total thickness of the seam	:	6.20 Mts.
Average seam gradient	:	1in 6.0

Working section	:	3.3 M along the floor
Nature of roof	:	Coal with a clay band (0.30 m)
Nature of floor	:	Grey sand stone
Supports in the face	:	4x800T Chock shields (IFS)
No. of supports at the face	:	101

3.2 Mining Method

In GDK 10A incline, retreating longwall method is being followed as mentioned above. In 3D2 panel, face length was 150 m and panel length was 432 m. Extraction was going on in lower section of coal bed for a height of 3 m. 101 IFS type of four leg shield capacity of 800T were being used for supporting the roof. Specification of shield support is as below:

Table 3.2: Specification of Shield Support

Support Capacity And Type	4*800T, IFS Chock Shield
Make	MECO International
Yield Pressure	43.4MPa (6400 psi)
Canopy Length	4.5 m
Open Height	33.6 m
Closed Height	1.65 m
Web Depth	0.6 m
Range	2.2-3.3 m
Canopy	4.5x1.5 m
Support density at 850 mm web & 3 m height	After cut 94.16T/m^2 Before cut 110T/m^2

Fig.3.3: Shield Support

Setting and yield pressure of shields were 300bar and 400bar respectively. For cutting the coal, a shearer of capacity of 800TPH with drum dia. 1.83m and web width 0.85 was being used. For conveying the coal from the face an AFC having capacity 1200TPH were used. Production of the panel was 1085T per day. Local fall and main fall were observed after a retreat of 41m and 72m respectively. Maximum subsidence observed was 1.1m.

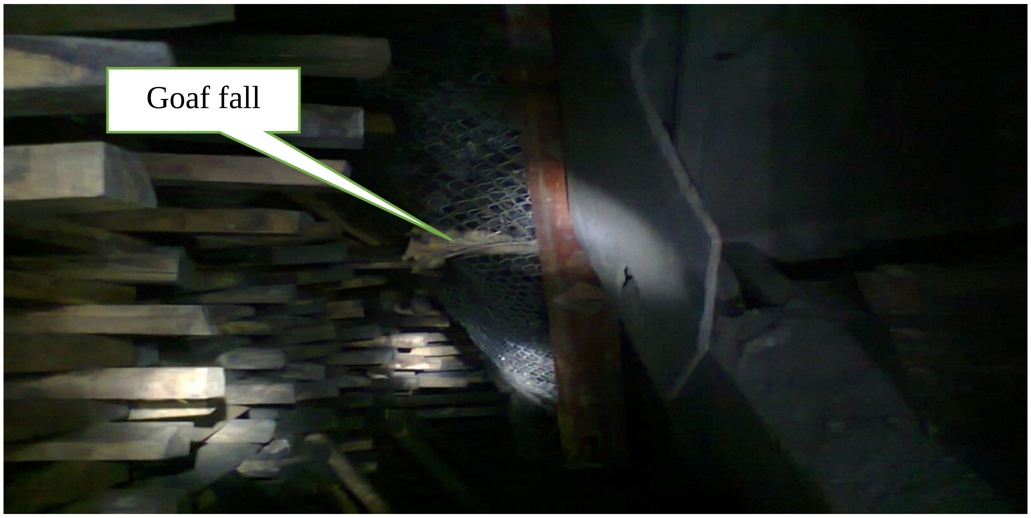

Fig.3.4: Goaf fall behind the shield

For shifting the shield, a wire with one long portion tightly inserted in ground was used. Bottom channel of shield as shown in figure below was tied with one end of a chain and other end of the chain was connected with free portion of wire rope ant hydraulic pressure was applied resulting in inward motion of channel producing forward motion in shield.

Fig.3.5: Channel for the purpose of shifting the shield

3.3 Investigation of chock shield Performance:

The performance of chock shield was investigated by separately measuring the closure of legs and the pressure changes in each individual leg of the chock shield supports. The leg closure of the chock shield was measured by measuring the leg exposure by using tape in every shift and being noted for further records. The leg pressure of the powered support was measured using the pressure indicators provided on the powered support. The pressure of both the rear legs was measured by only one indicator.

CHAPTER 4

FIELD OBSERVATION

Leg Pressure and Leg Closure

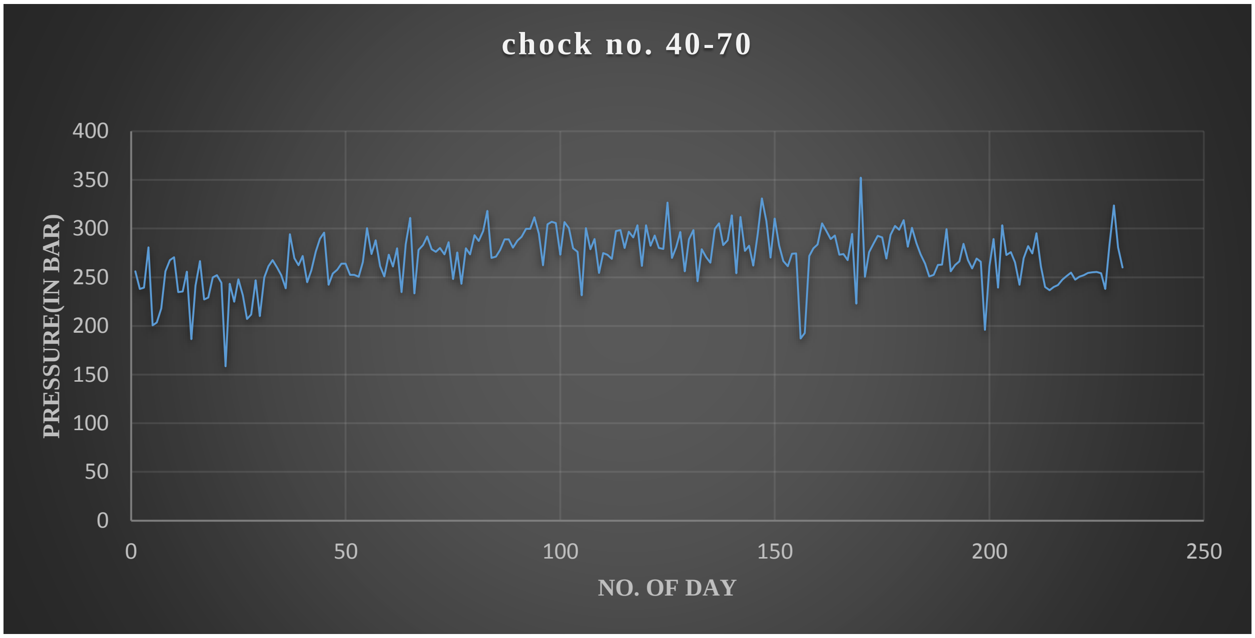

Fig.4.1: Plot of average leg pressure of chock no. 40-70

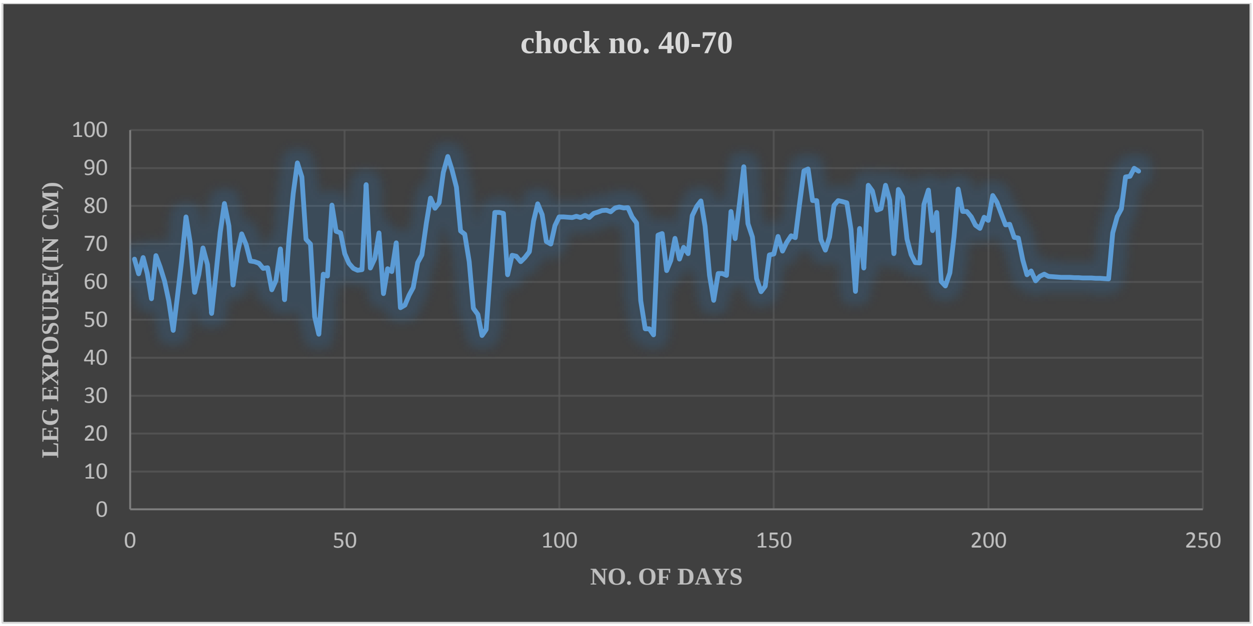

Fig.4.2: Plot of average leg exposure of chock no. 40-70

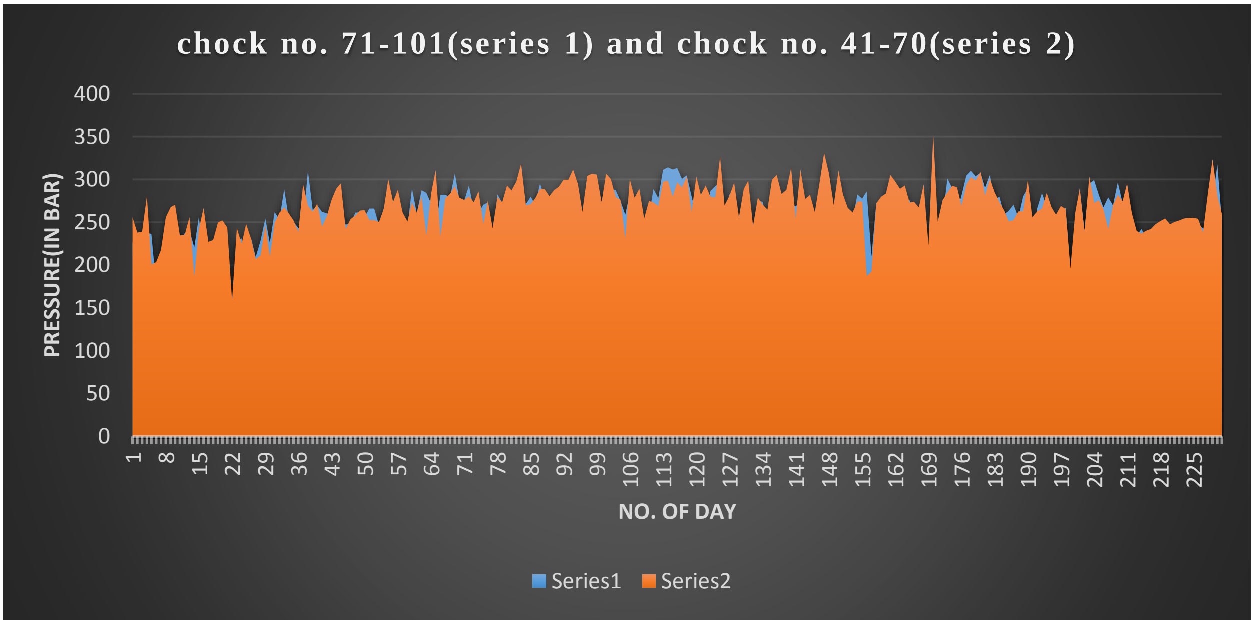

Fig.4.3: Plot of average leg pressure of chock no. 71-101 and chock no. 41-70

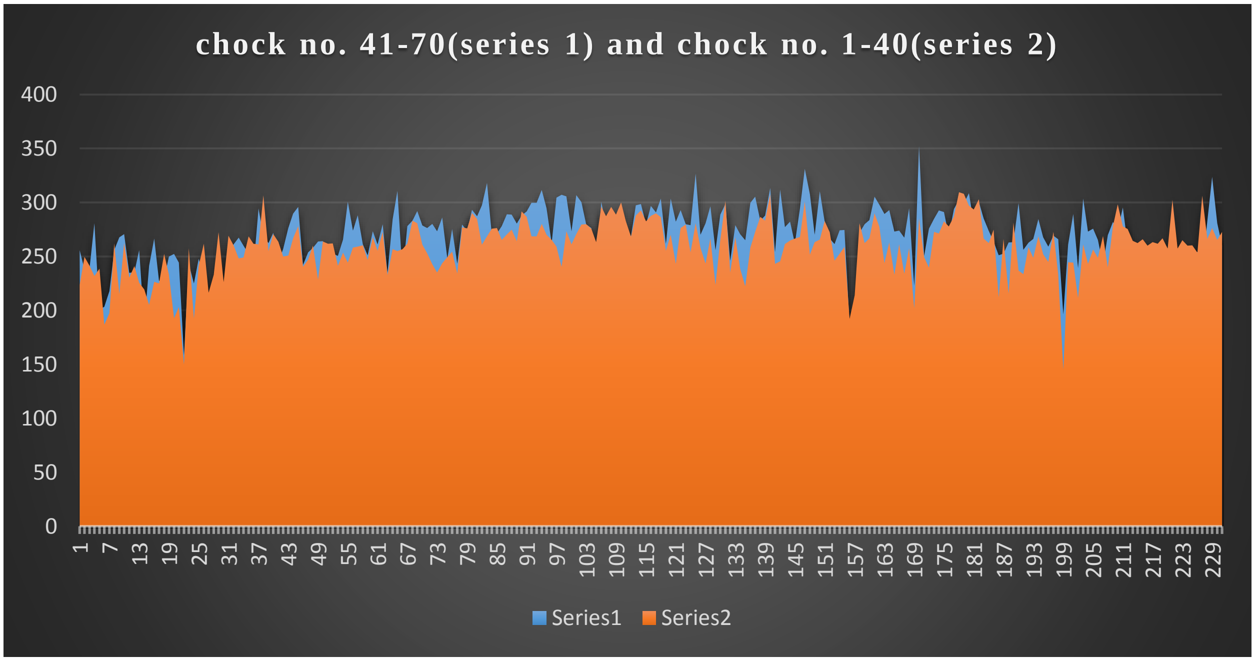

Fig.4.4: Plot of average leg pressure of chock no. 41-70 and chock no. 1-40

Leg Pressure and Leg Exposure at the time of Local Fall and Main Fall

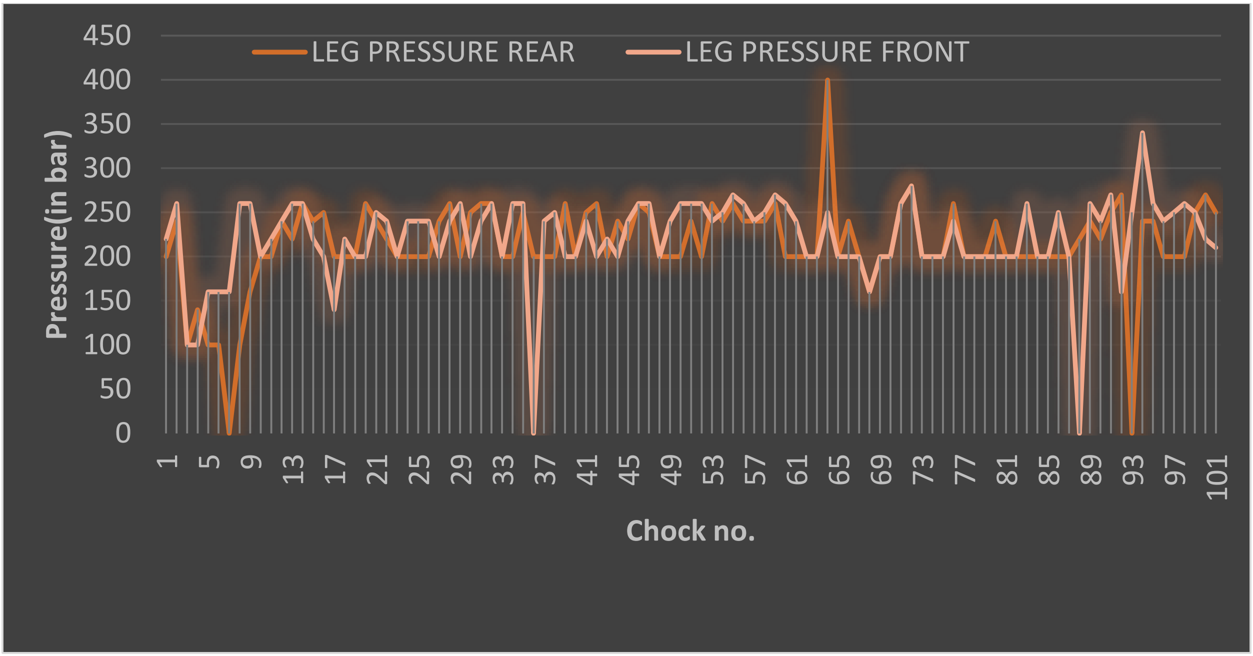

Fig.4.5: Leg Pressure at the time of Local Fall at a Distance of 15m

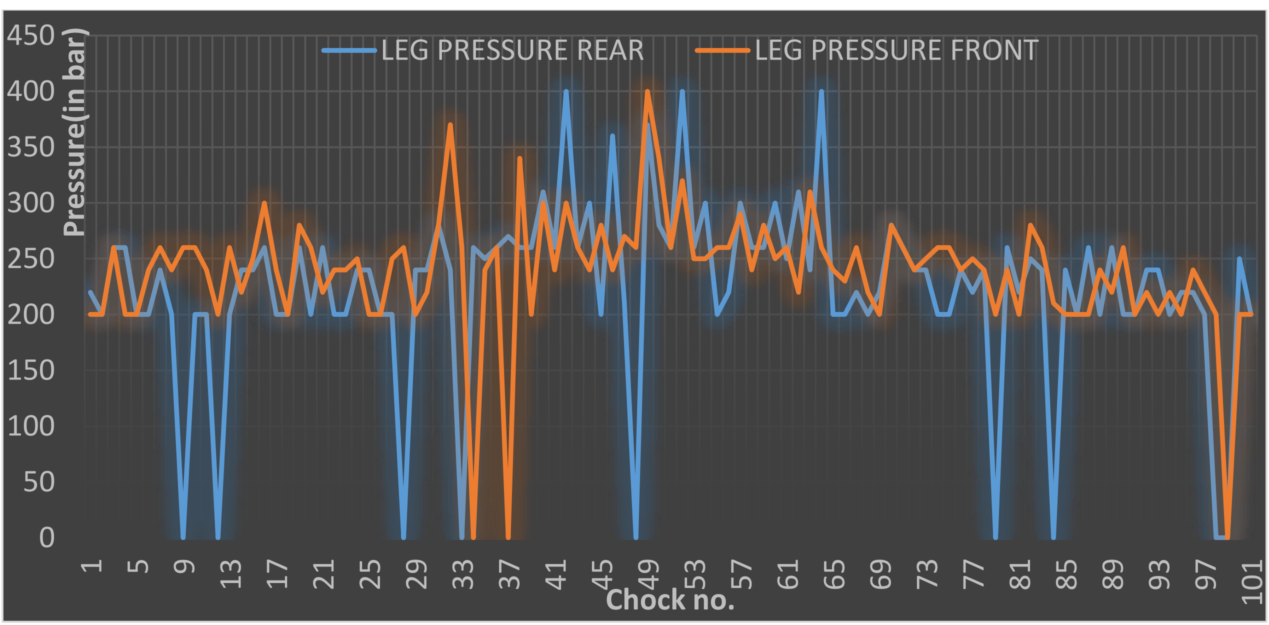

Fig.4.6: Leg Pressure at the time of Main Fall at a Distance of 61m

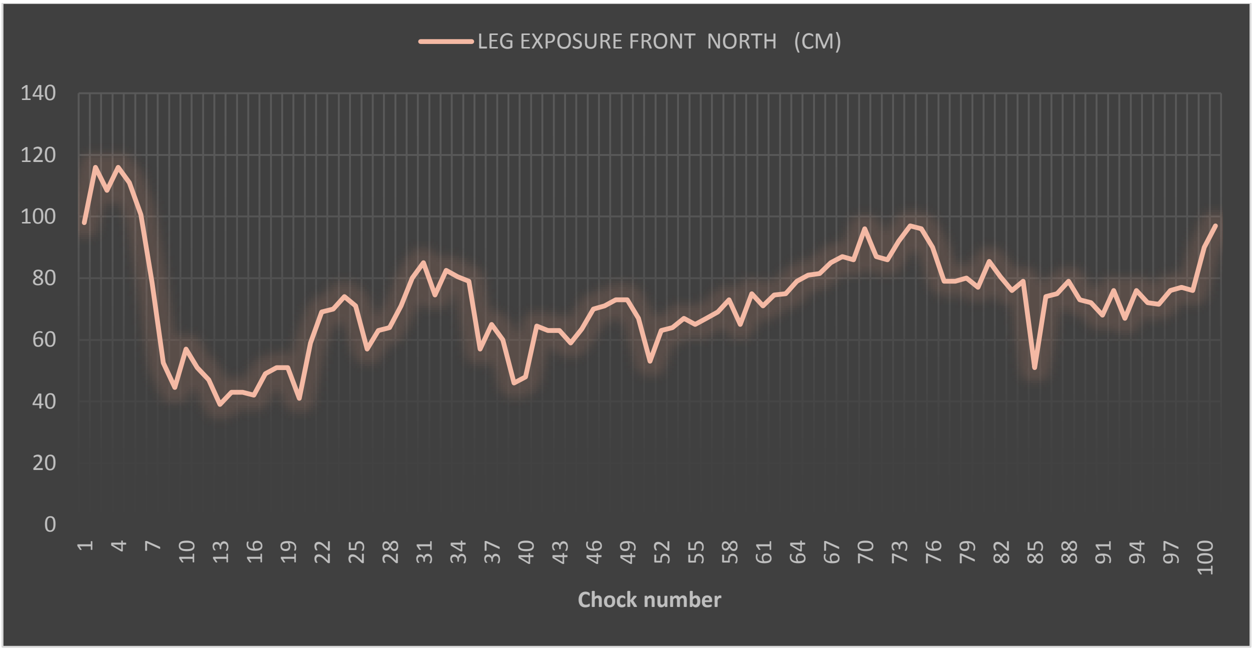

Fig.4.7: Leg Exposure at the time of Local Fall at a Distance of 15m

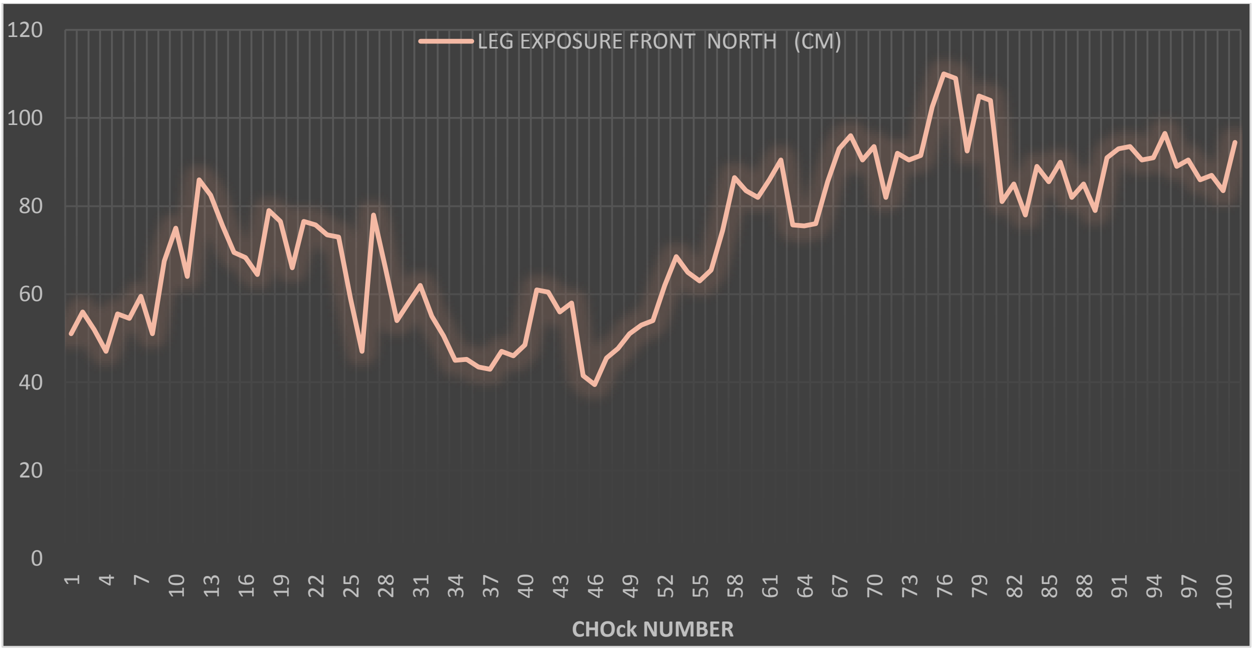

Fig.4.8: Leg Exposure at the time of Local Fall at a Distance of 61m

Table 4.1: Condition of Chock Shield as the Face Advances

S.No	Weighting	Date /Shift	Avg. retreat	Area of expo.	Observations
1	Local	7-9-12 / PRE	15.4 m	1652.75 m2 (10.75x154.20)	• C70 to T.G entire stone roof fallen in the goaf (up to 1 m thick of stone). • No bleeding
2	Local	24-9-12 / PRE	36.6 m	2621.40 m2 (17.00x154.20)	• C45 to C98 Coal roof behind the chock shield fallen in the goaf (up to 1m thick of stone). • No bleeding • Stone of 5-6 m fallen in goaf.
3	Local	28-9-12 / III	52.5 m	4001.49 m2 (25.95x154.20)	• C02 to C22 stone roof fallen in the goaf (up to 1 m thick stone). • No bleeding
4	Local	06-10-12 / III	58 m	10006 m2 (39.40x154.20)	• C50 to C80 stone roof fallen in the goaf (up to 1 m thick).
5	Goaf	09-10-12 / III	61.85 m	10633 m2 (68.95x154.20)	• Load observed in chocks C45-C80.Pressure(350.38)
7	MAIN weighting	19-10-12 / P, I, II, III	78.1 m		• Weighting observed from C55 to C73 • Bleeding of supports C58 to C83
8	Periodic weighting	27-11-2012 / P, I, II, III	95.2 m		• Bleeding of supports from C55-71

4.1 Chock Behavior

4.1.1 Leg Pressure

a. From Fig.4.7 and Fig.4.8, it was observed that leg pressure in chock no. 41-70 were more than other sections i.e. shields in middle sections were more loaded than sides.

b. From Fig.4.1, Fig.4.2 and Fig.4.3, it was observed that after a regular interval, there was a fall in leg pressure.

c. Maximum rear leg pressure and front leg pressure at the time of local fall at a distance of 15 m was 400 bar and 340 bar respectively.

d. During major fall condition 27% of chock shield were loaded upto 800T. During normal periods, maximum pressure was about 340 bar.

e. Maximum rear leg pressure and front leg pressure at the time of main fall at a distance of 61 m was 400 bar in both leg.

f. During extraction of the panel, maximum pressure on the chock shield was 490 bar respectively.

4.1.2 Leg Closure

a. Leg exposure was increasing and decreasing after a regular interval.

b. During extraction of the panel, maximum leg closure was 600 mm.

c. During local fall at a distance 15 m, maximum leg closure was 500 mm.

d. During main fall at a distance 61 m, maximum leg closure was 600 mm.

CHAPTER 5

NUMERICAL MODELLING

5. NUMERICAL MODELLING

The longwall panel was modeled using FLAC5.0 with face length of 150 m and panel length of 400 m at 150 m, 250 m, 350 m, 600 m, 900 m and 1200 m depth at a face advance of 6 m, 20 m, 40 m, 60 m, 80 m, 100 m and 150 m with an initial opening of 6 m. At face chock shield support was simulated with load of 749 tons. The longwall panel was simulated to plot their vertical displacement and vertical stress contours over support. Two type of simulation were done; first was taking on coal of thickness 6.5 m only and the second was with clay band in the immediate roof. With clay band was the original field condition and this was simulated for a depth of 250 m with face advance of 6 m, 20 m, 40 m and 60 m and the results coming were compared to field data.

5.1 Sequence of Modeling

1. Development of the total seam layout at different depths above mentioned with the coal layer 6.5 m high and an extraction height of 3 m.

3. Development of longwall face at different positions mentioned above.

4. Installation of chock shield supports with parameters as:

Compressive yield = 7350000N

Stiffness = 0.5 mm per ton

Along the two edges a typical roller type boundary condition was given as parameter and bottom was fixed along both X and Y direction... To estimate the in situ stress the following formula was adopted and the horizontal and vertical stress were simulated.

$$\text{Vertical stress} = \rho \times H \; \ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

Horizontal stress = 3.75 + 0.015 H ………… (ii)

Where, ρ = specific weight of the overlying rock mass and

H = depth cover

Gravitational loading was simulated by the model itself. To generate pre-mining conditions, the models were run for an initial analysis to generate the in situ stresses. Then longwall openings were added to the model and the simulation were executed to obtain equilibrium conditions. The models were executed to the following coal and sandstone parameters. It was assumed that roof convergence was equal to total leg closure.

Table 5.1: Property of Coal and Sandstone

Property	Coal	Sandstone
Bulk Modulus	3.67 GPa	6.67 GPa
Shear Modulus	2.2 GPa	4.0 GPa
Density	1430 kg/m3	2100 kg/m3
Tensile Strength	1.86 MPa	9.0 MPa
Cohesion	1.85 MPa	6.75 MPa
Friction Angle	30^0	45^0

Grid Generated to Simulate the Model for Different Stages of Extraction at a Depth 250 m

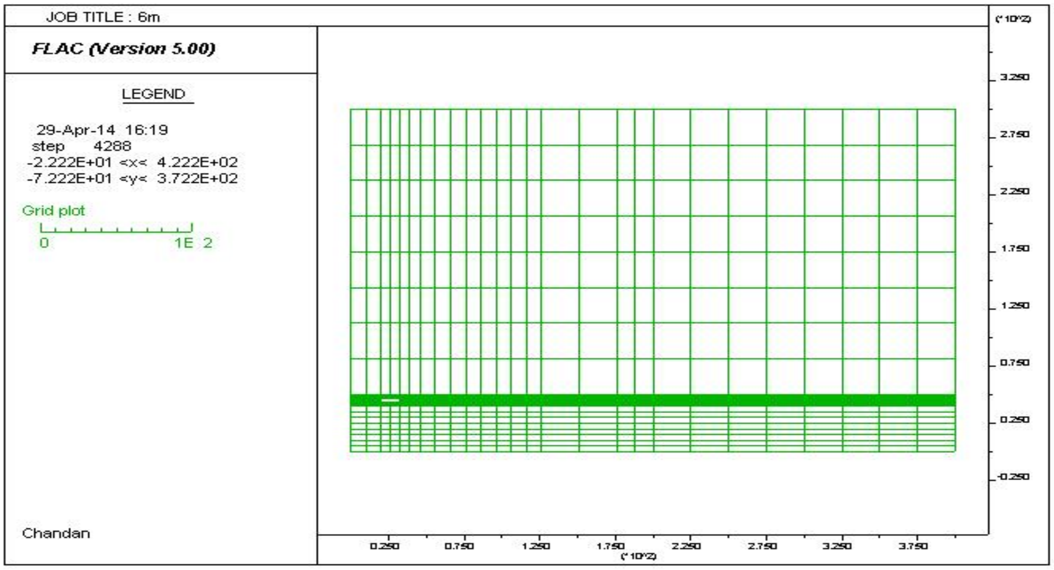

Fig.5.1: Grid generated to simulate 6 m of extraction

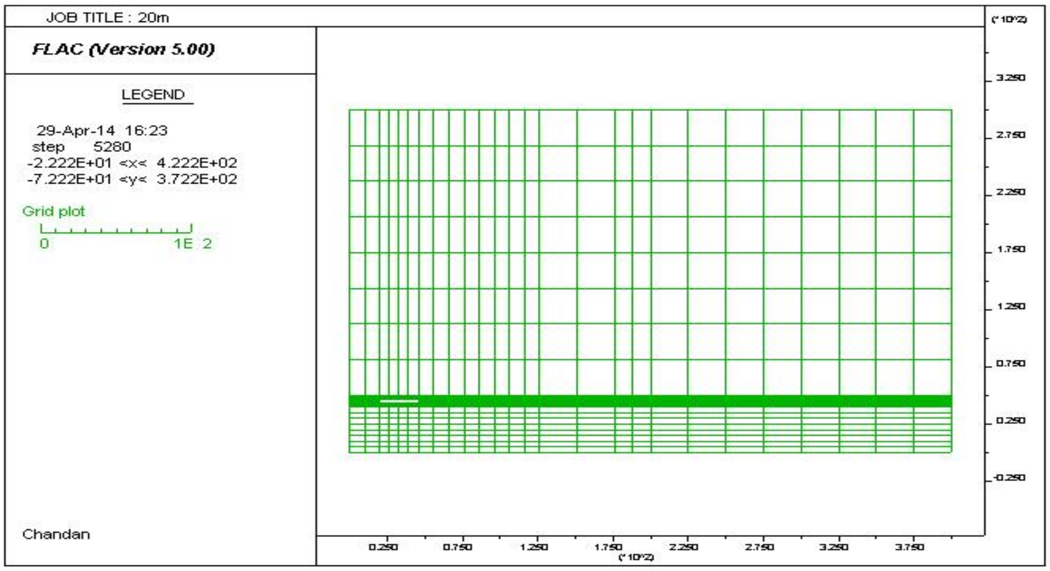

Fig.5.2: Grid generated to simulate 20 m of extraction

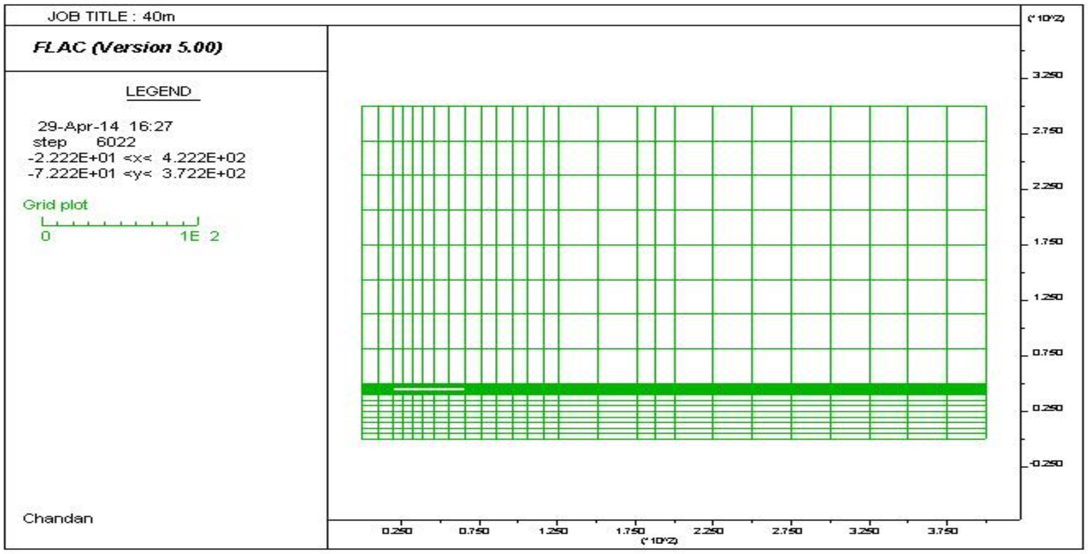

Fig.5.3: Grid generated to simulate 40 m of extraction

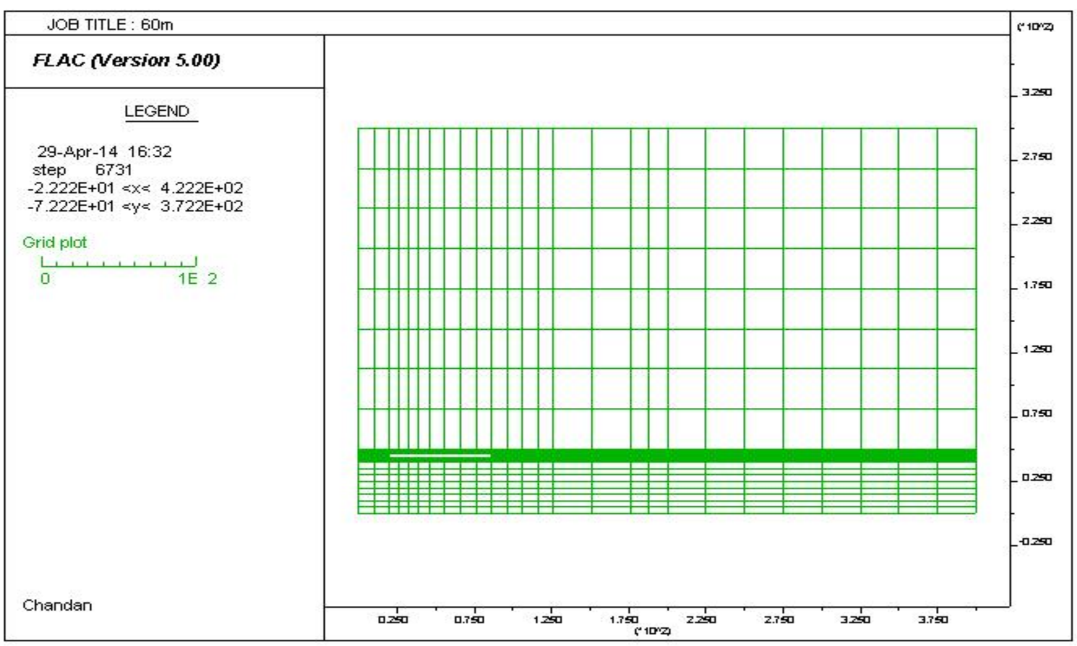

Fig.5.4: Grid generated to simulate 60 m of extraction

Modelling Plots for Roof sag and Vertical Stress over the Supports for 250 m Depth

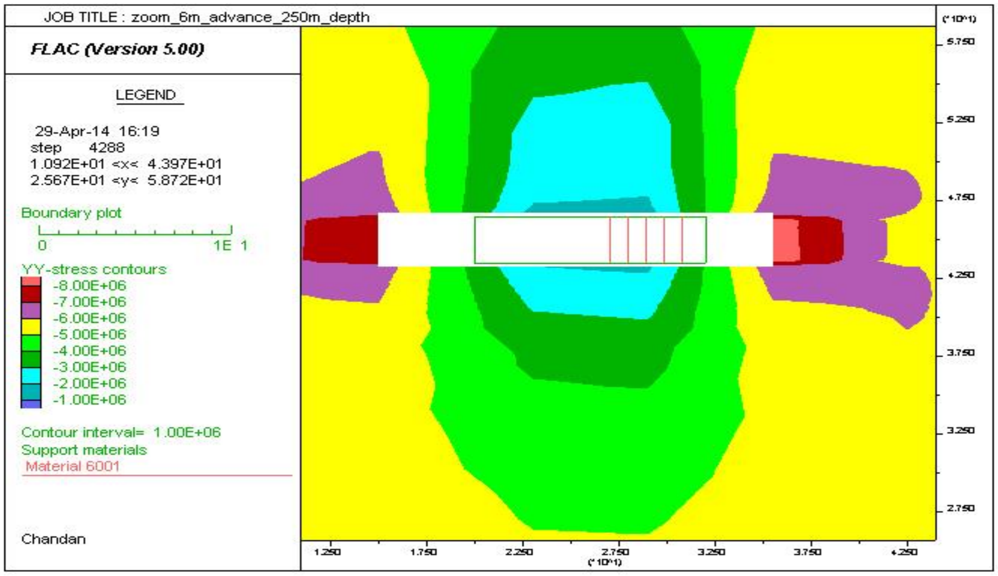

Fig.5.5: Vertical Stress over the shield supports after 6 m face advance

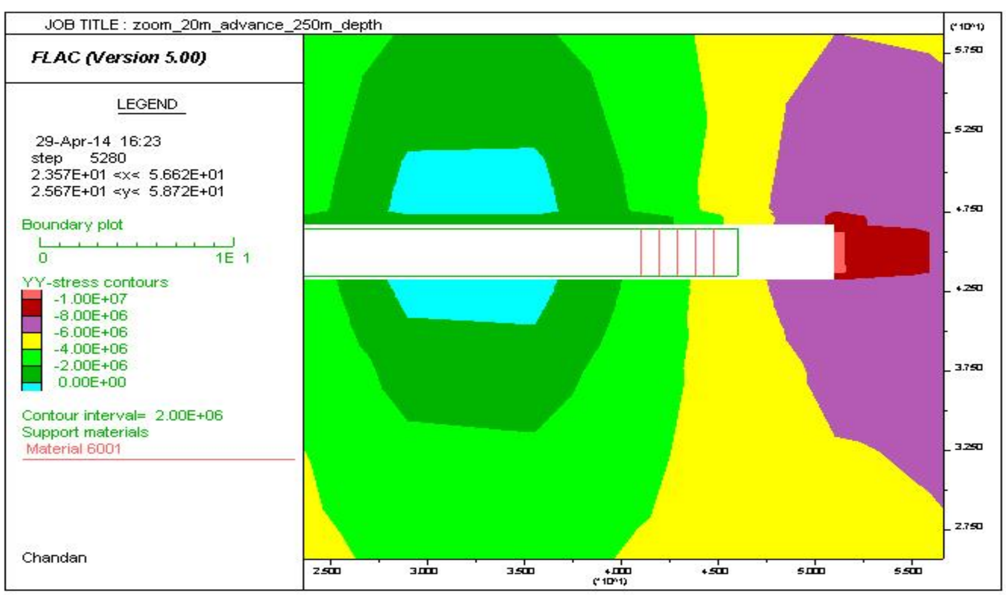

Fig.5.6: Vertical Stress over the shield supports after 20 m face advance

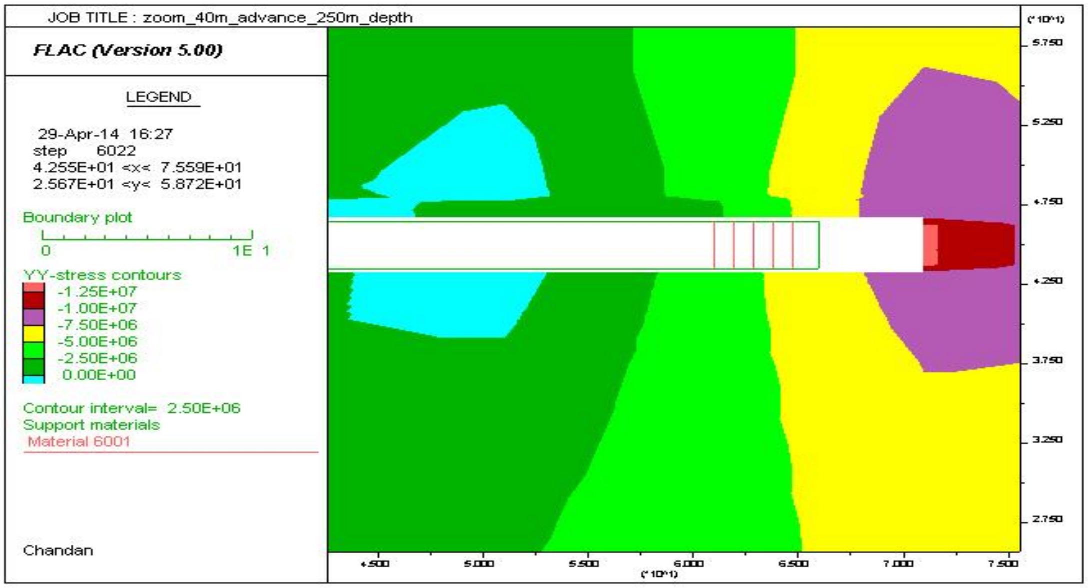

Fig.5.7: Vertical Stress over the shield supports after 40 m face advance

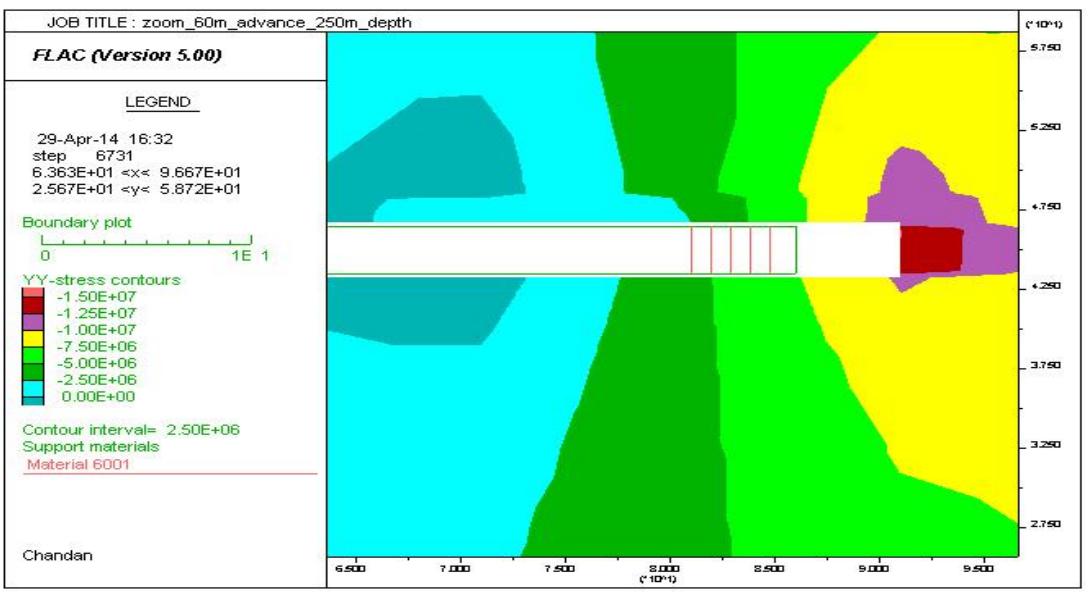

Fig.5.8: Vertical Stress over the shield supports after 60 m face advance

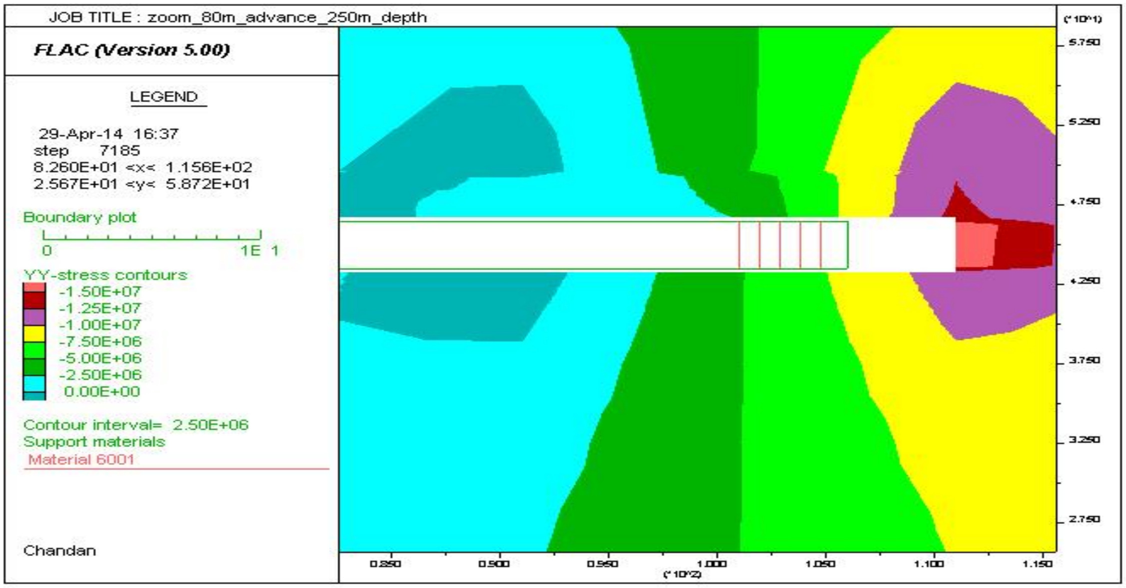

Fig.5.9: Vertical Stress over the shield supports after 80 m face advance

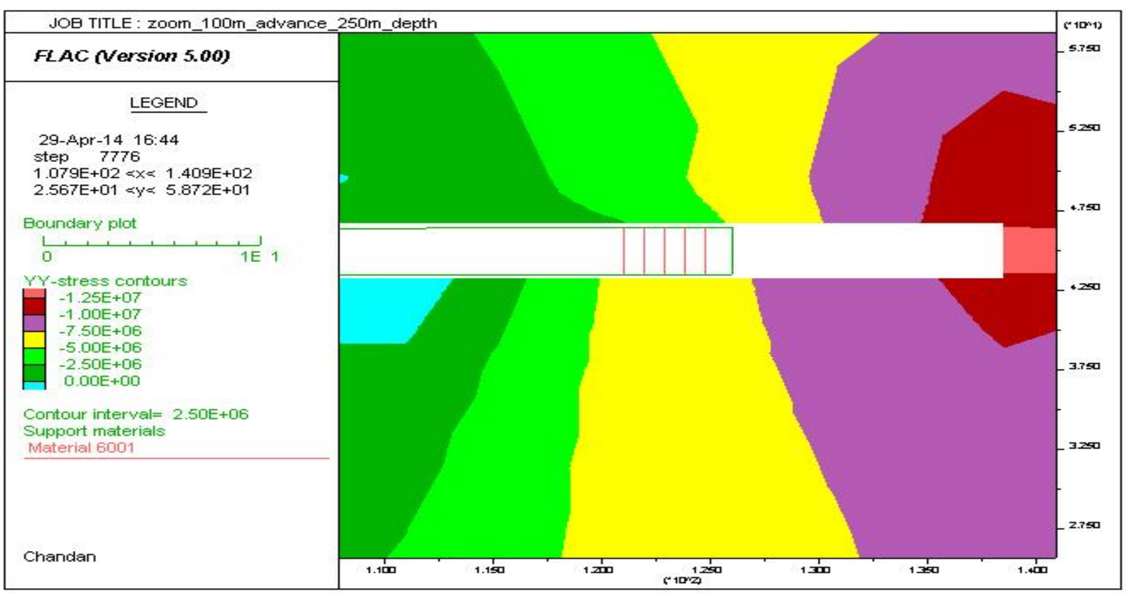

Fig.5.10: Vertical Stress over the shield supports after 100 m face advance

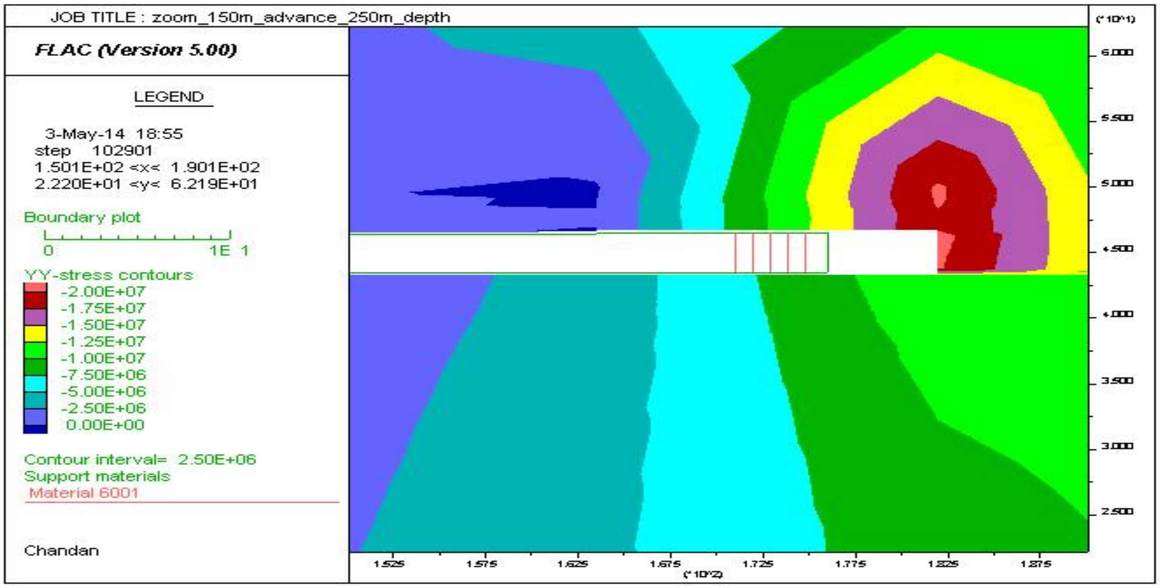

Fig.5.11: Vertical Stress over the shield supports after 150 m face advance

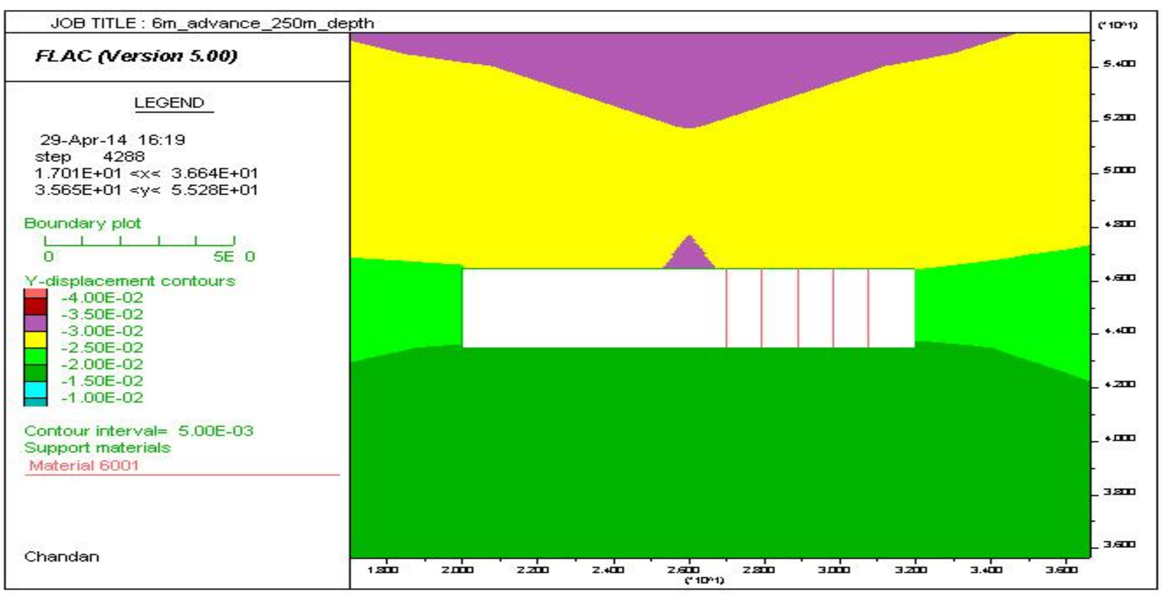

Fig.5.12: Roof sag over the shield supports after 6 m face advance

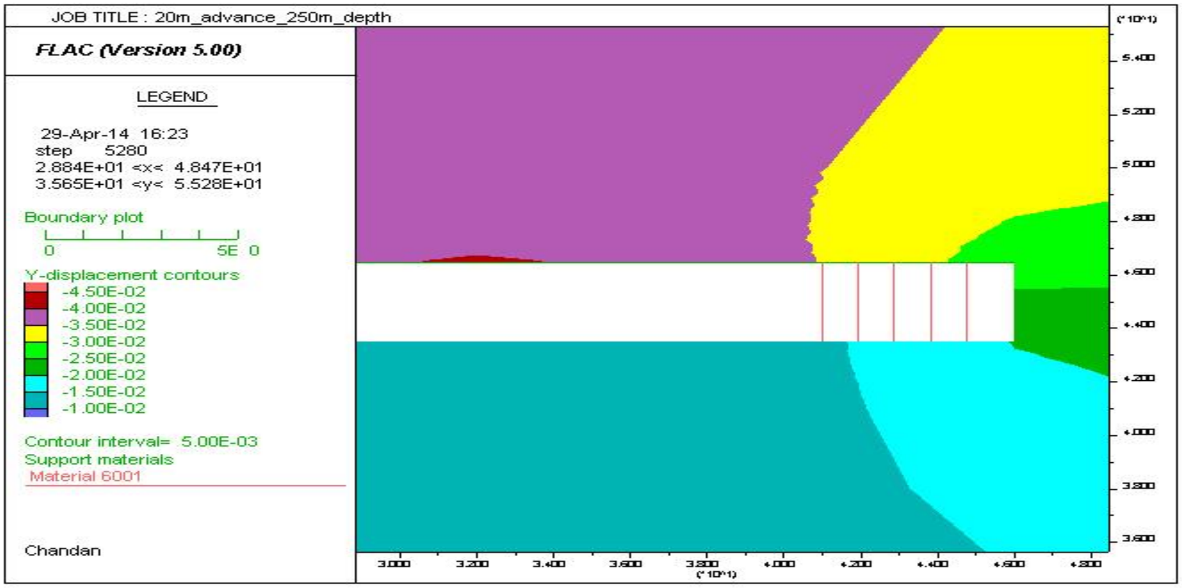

Fig.5.13: Roof sag over the shield supports after 20 m face advance

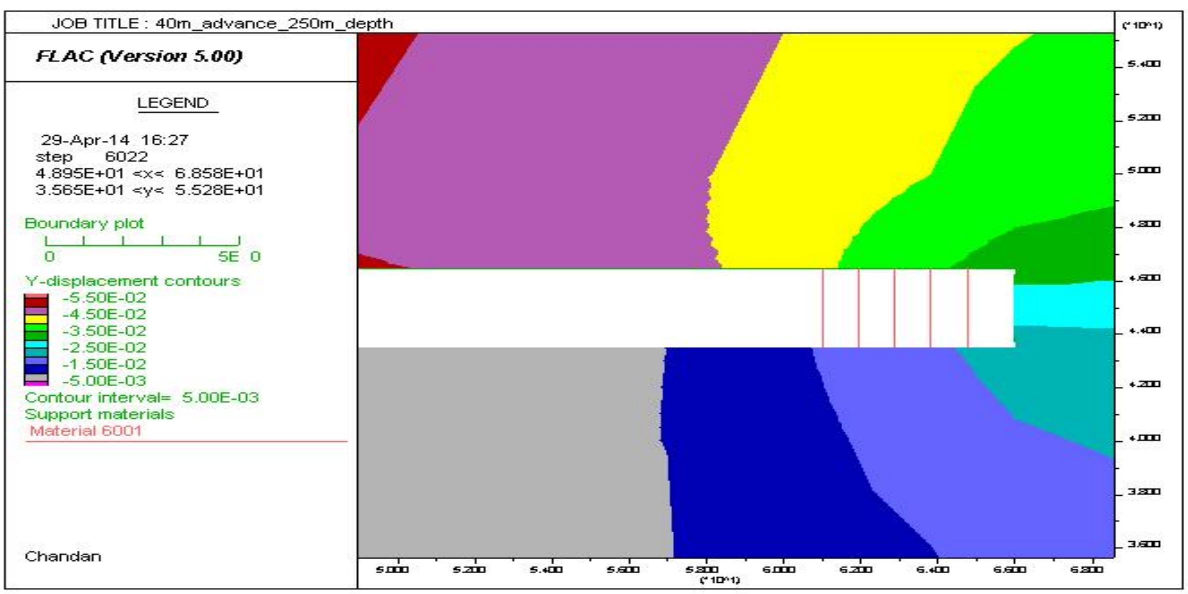

Fig.5.14: Roof sag over the shield supports after 40 m face advance

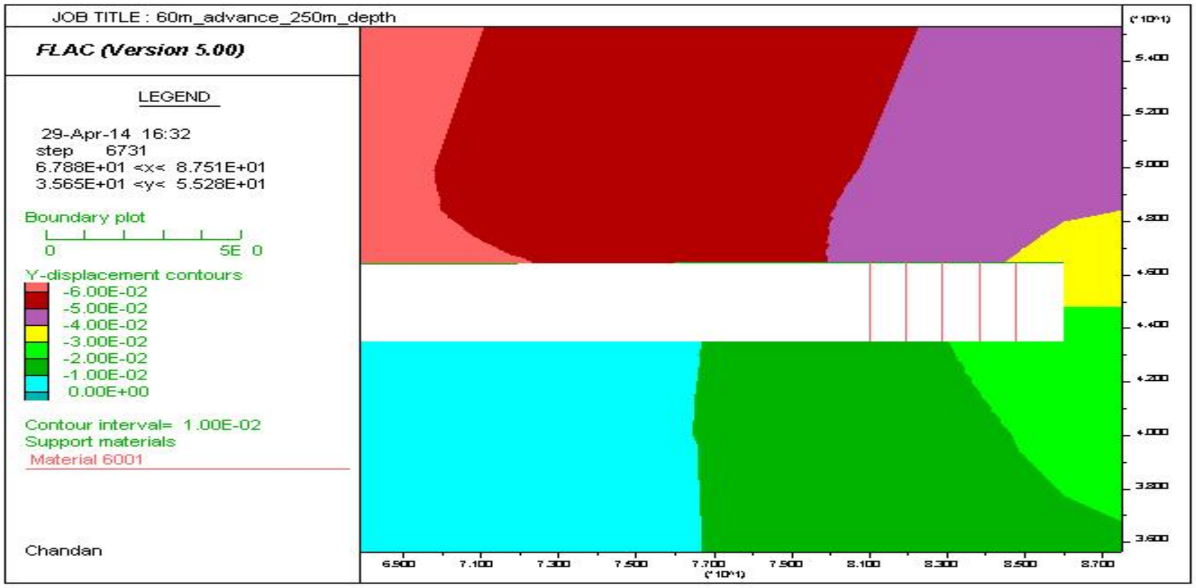

Fig.5.15: Roof sag over the shield supports after 60 m face advance

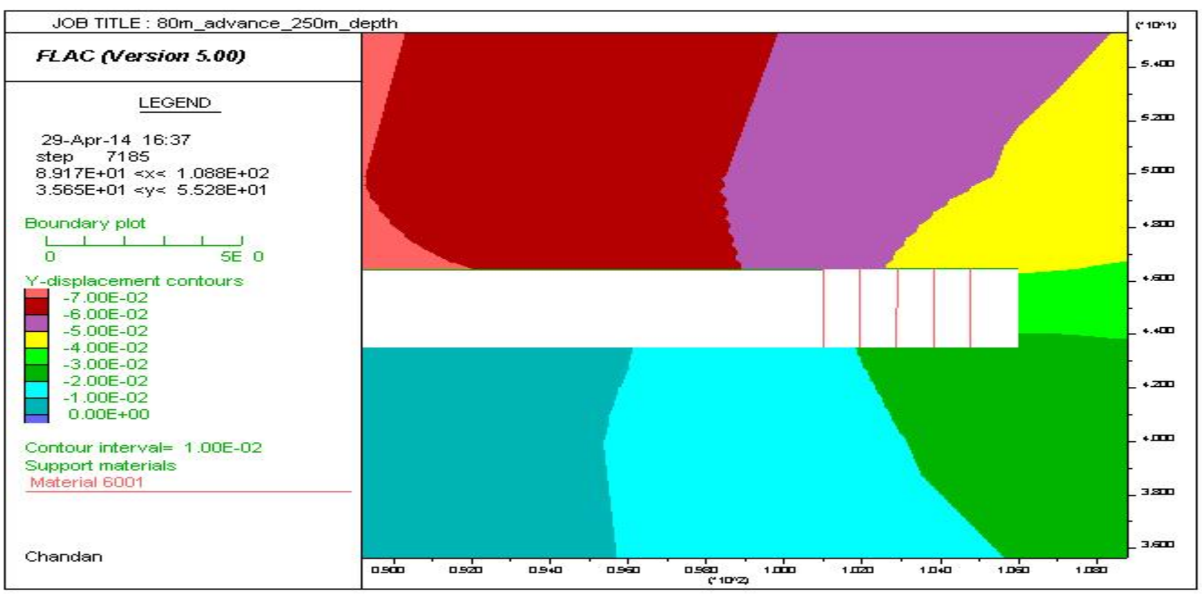

Fig.5.16: Roof sag over the shield supports after 80 m face advance

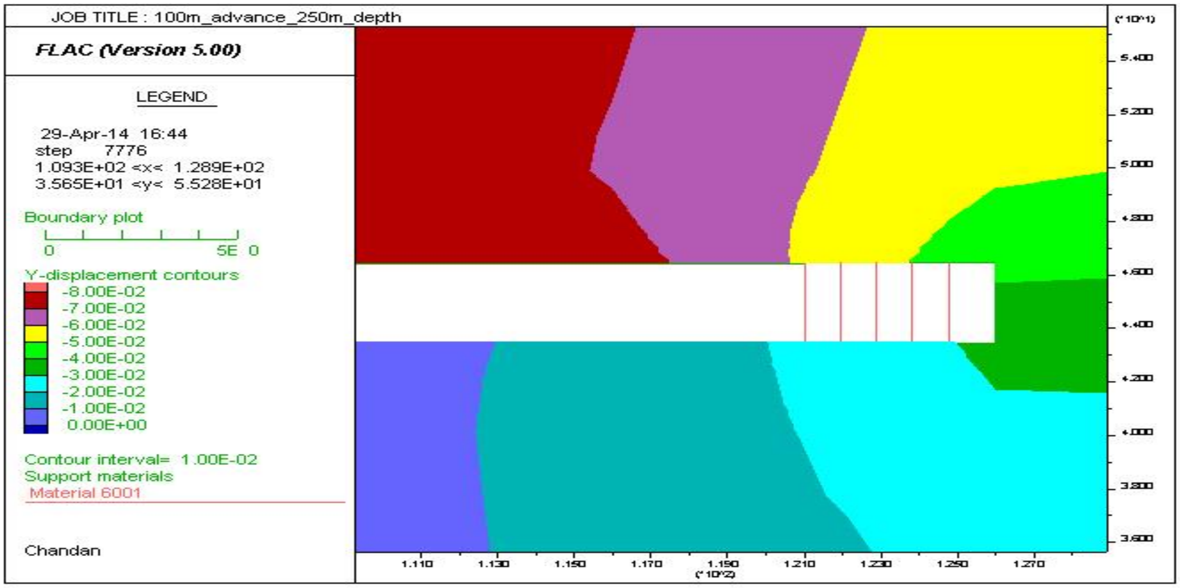

Fig.5.17: Roof sag over the shield supports after 100 m face advance

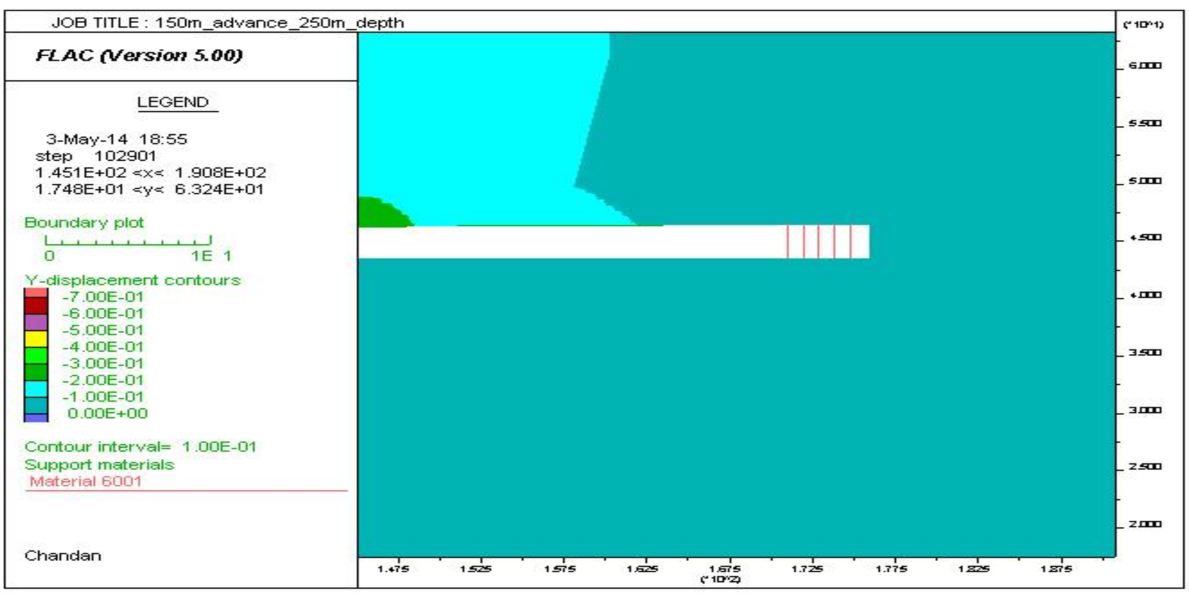

Fig.5.18: Roof sag over the shield supports after 150 m face advance

Modelling Plots for Roof sag and Vertical Stress over the Supports for 250 m Depth in case of Clay Band Included i.e. in actual field condition

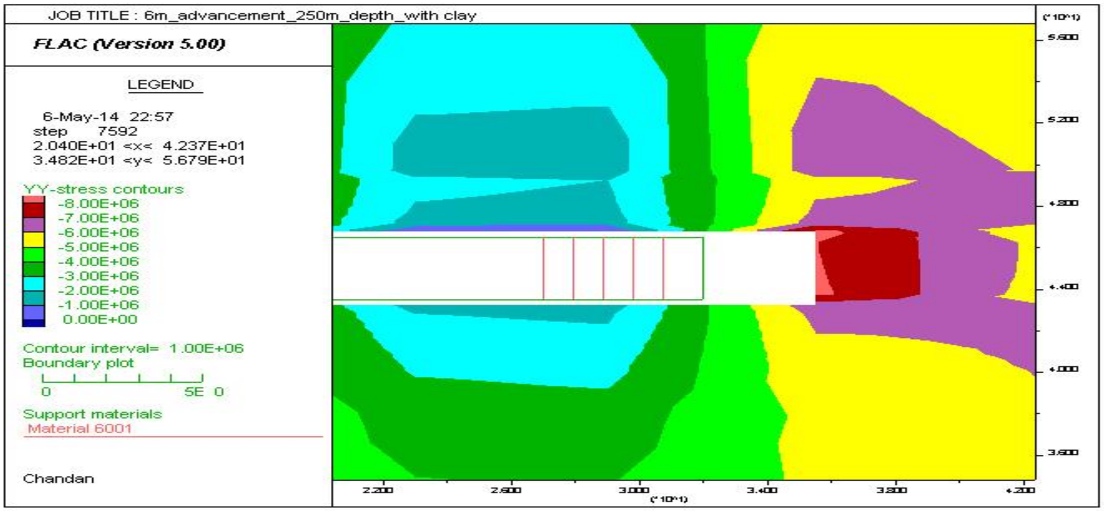

Fig.5.19: Vertical Stress over the shield supports after 6 m face advance

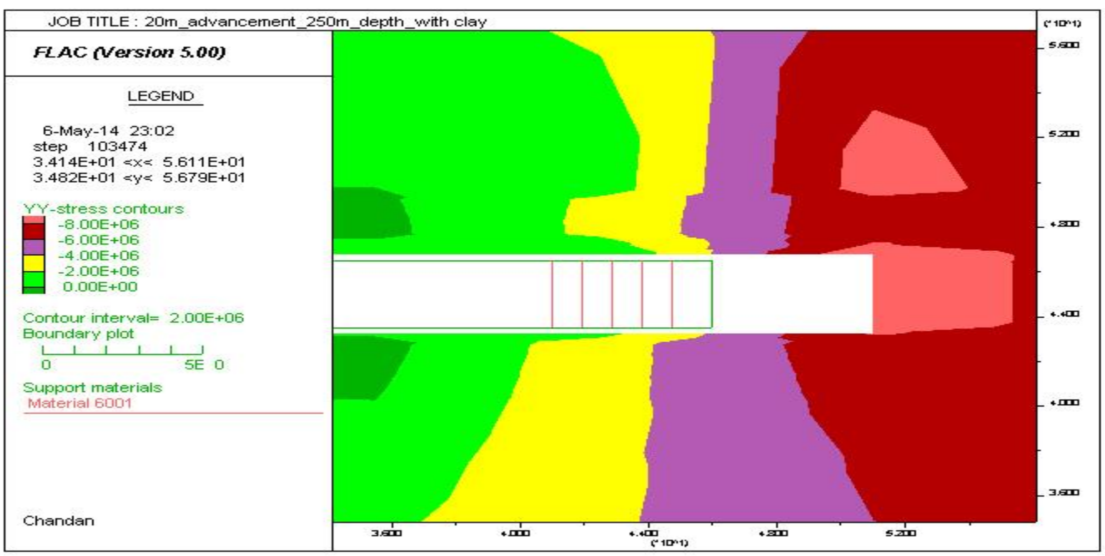

Fig.5.20: Vertical Stress over the shield supports after 20 m face advance

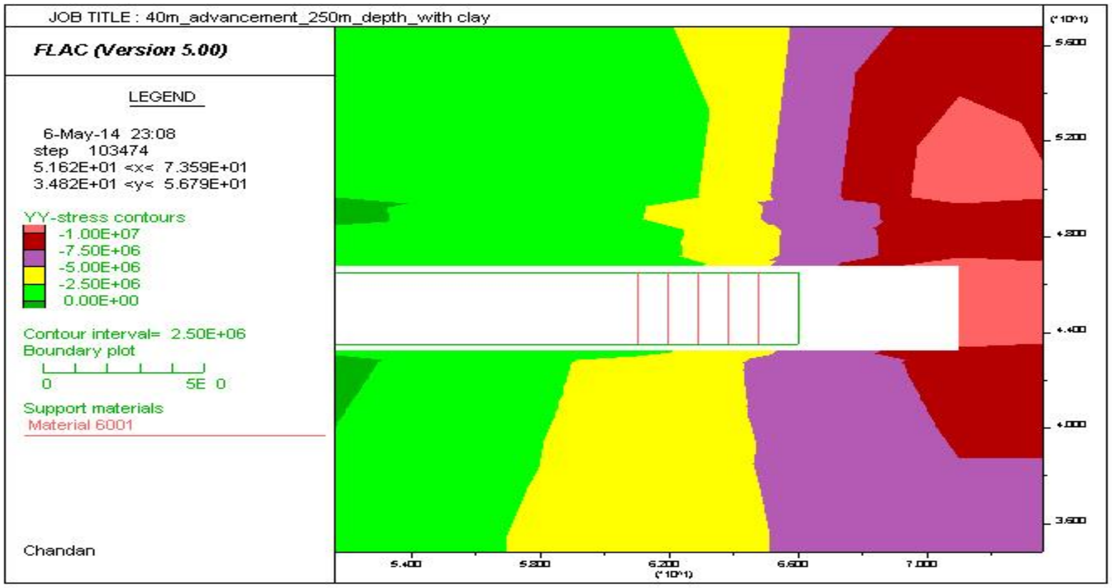

Fig.5.21: Vertical Stress over the shield supports after 40 m face advance

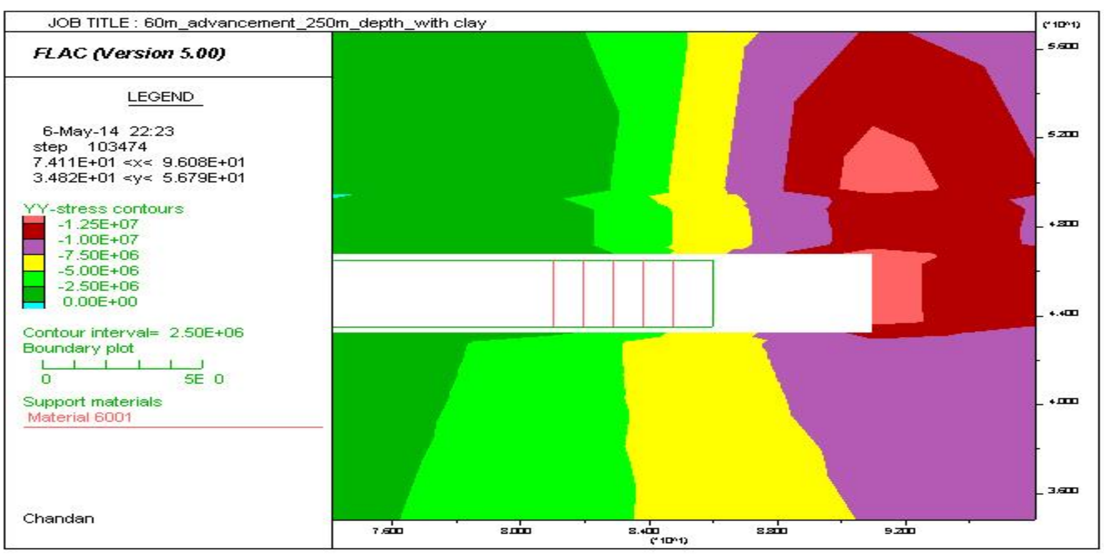

Fig.5.22: Vertical Stress over the shield supports after 60 m face advance

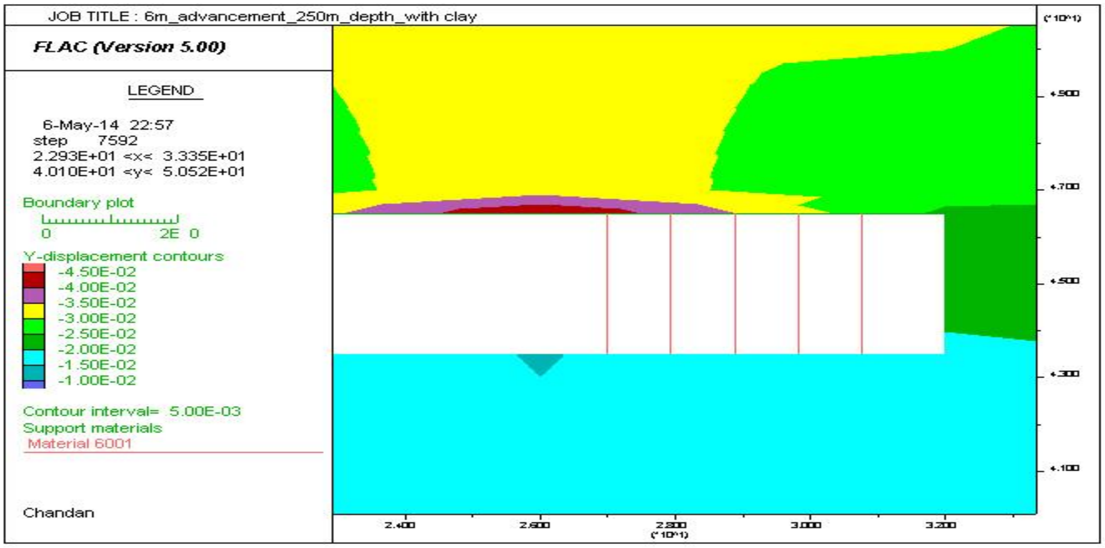

Fig.5.23: Roof sag over the shield supports after 6 m face advance

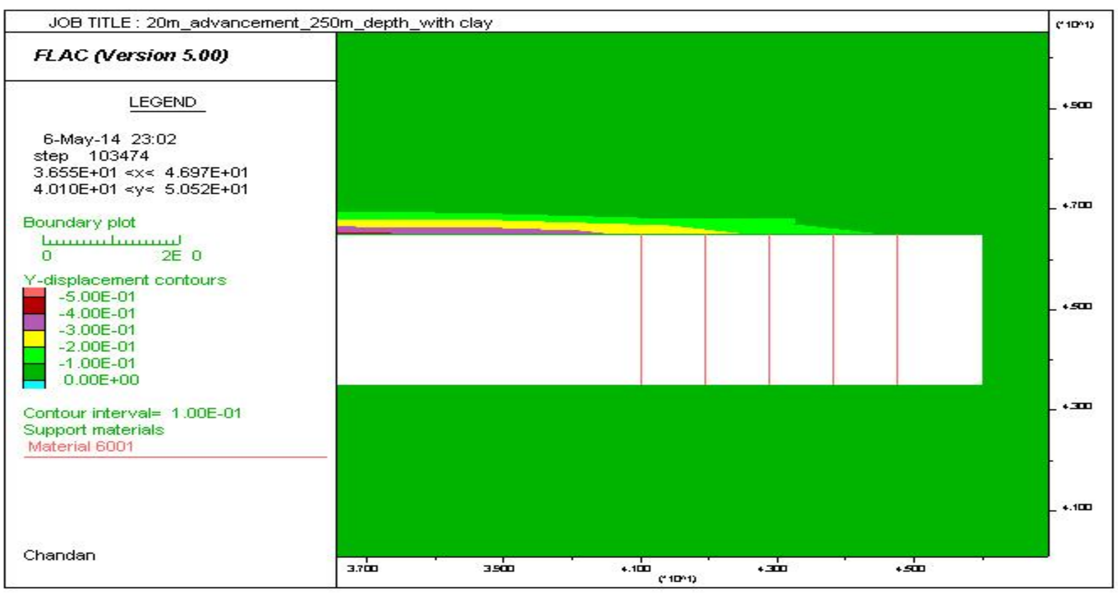

Fig.5.24: Roof sag over the shield supports after 20 m face advance

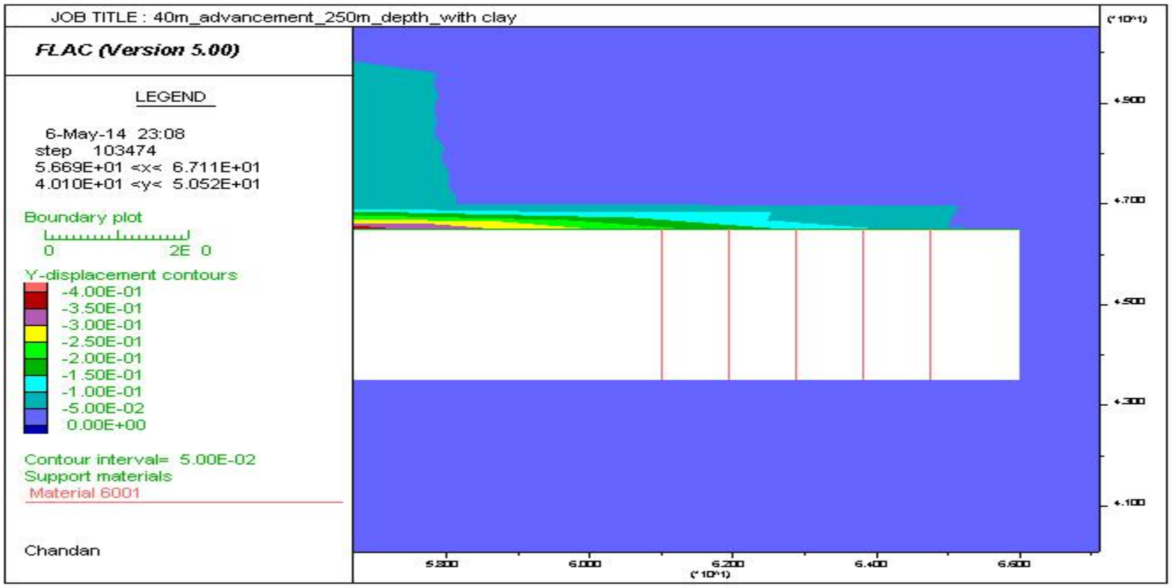

Fig.5.25: Roof sag over the shield supports after 40 m face advance

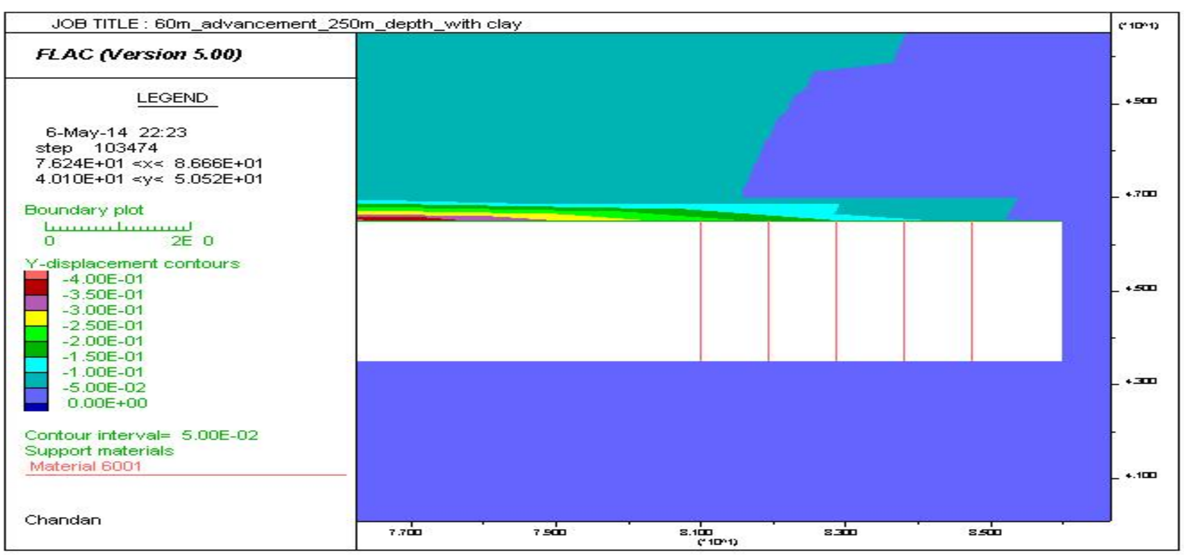

Fig.5.26: Roof sag over the shield supports after 60 m face advance

Table 5.1: Vertical stress over supports at different face advance and depth as per numerical model

Face advance → / Depth ↓	Vertical Stress (in MPa)						
	6 m	**20 m**	**40 m**	**60 m**	**80 m**	**100 m**	**150 m**
150 m	2	2.6	3.6	3.6	4.5	4	7
250 m	2.4	3.2	5	5.5	6	4.5	11.5
350 m	2.8	4	6	6	7	5	17
600 m	5.5	7	9	9	10	7	28
900 m	7	7	12	14	16	10	14
1200 m	8	8	16	18	18	14	50

Note: For 250m depth, modelling was also done for face advance of 125m and 174m and the vertical stress was found to be 7.5MPa and 4MPa respectively.

Table 5.2: Roof sag over supports at different face advance and depth as per numerical model

Face advance → / Depth ↓	Roof sag (in mm)						
	6 m	**20 m**	**40 m**	**60 m**	**80 m**	**100 m**	**150 m**
150 m	20	23	26	32	38	40	60
250 m	30	34	37	48	54	56	100
350 m	50	50	70	100	100	500	610
600 m	100	100	110	200	240	600	800
900 m	160	200	200	250	250	700	1000
1200 m	250	250	300	500	700	1000	1500

Note: For 250 m depth, modelling was also done for face advance of 125 m and 174 m and the Roof sag was found to be 56 mm and 160 mm respectively.

Observation

a. Vertical stress was increasing with face advance but for interval 80 m to 100 m, a fall in vertical stress was observed. For 250 m depth, stress in this interval was varying from 6MPa to 4.5MPa.

b. Vertical stress and roof sag above the support was increasing as the depth was varying from 150 m to 1200 m and maximum found was 50 MPa and 1500 mm respectively at 1200 m depth and 150m face advance indicating a pressure beyond the yielding pressure of choosen support resulting in failure of the choosen support at 1200 m depth.

Comparison of Modeling Results with Field Data at a depth of 250 m in case of clay bed

Table 5.3: FLAC Results vs. Field Investigation Data

Face advance	**FLAC result(maximum roof sag over support in mm)**	**Field result(maximum roof sag over support in mm)**	**Maximum vertical stress over support (in MPa)**
6 m	45	55	3
20 m	300	310	4
40 m	250	230	5
60 m	250	320	7.5

CHAPTER 6

ANALYSIS

6. ANALYSIS

6.1 Behavior of Shield

Chock Shields in middle section were more loaded than sides because roof are supported by coal, goal material, shields and also by rocks in sides; so as we move further from middle section, contribution of rock in supporting the roof will increase.

Leg closure and leg pressure were decreasing in some intervals because decrease in load coming on shield due to roof fall.

6.2 Numerical Model

From Table 5.3, it can be seen that actual field values were greater than the FLAC generated values due to:

a. Failure to simulate all the geological features present in the seam.
b. The deformation caused due to the vibrations generated from the shearer.
c. The pressure caused due to presence of water table or aquatic sources.

The results of roof sag collected from FLAC modelling shows a regular increase while field data shows increment and decrement both after some regular intervals. The reason may be that FLAC produces a continuum modelling in which immediate and main roofs never break (it only sag) resulting in gradual increase in roof sag.

The results of vertical stress over the support collected from modelling shows a decrease in stress in between 80 m-100 m face advance due to occurring of roof fall. From modelling data of 250 m depth, it can be seen that there is a decrease in vertical stress in between 80 m-100 m and 150 m-174 m face advance.

CHAPTER 7

CONCLUSION

7. CONCLUSIONS

Based on the observation of the field data and output obtained from FLAC, the following conclusions are drawn:

a. An increasing rate of roof sag was observed from the results of the simulated models as the seam is extracted due to generation of continuum model resulting in lack of breaking of roof.

b. Vertical stress was increasing with face advance but for interval 80 m to 100 m, a fall in vertical stress was observed. For 250 m depth, stress in this interval was varying from 6MPa to 4.5MPa.

c. Vertical stress and roof sag above the support was increasing as the depth was varying from 150 m to 1200 m and maximum found was 50 MPa and 1500 mm respectively at 1200 m depth and 150m face advance indicating a pressure beyond the yielding pressure of choosen support resulting in failure of the choosen support at 1200 m depth.

d. Maximum rear leg pressure and front leg pressure at the time of local fall at a distance of 15m was 400 bar and 340 bar respectively.

e. Maximum rear leg pressure and front leg pressure at the time of main fall at a distance of 61 m was 400 bar for both leg.

f. During major fall condition 27% of chock shields were loaded upto 800T. During normal periods, maximum load was about 680T.

g. During extraction of the panel, maximum leg closure and leg pressure were 600 mm and 490 bar respectively.

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